



李安執導電影 飲食男女

餐飲美食策劃總監 林慧懿疫情期間關心您! 呆在家裡別出門!為了健康, 要多運動, 更要增加免疫力, 建議您早上美國靈芝尊, 晚上特效養肝素。靈芝尊又稱為養命仙草, 可以祛病強身, 特效養肝素幫助了很多B肝C肝脂肪肝的人。我的老媽90多歲了, 還耳聰目明, 就是靠靈芝尊, 養肝素和特效眼明素, 幫助她有精神, 有體力。癌症放化療輔助的朋友再加服2粒抗癌先鋒199。
美國蟲草至尊效果更強噢!



学术展望

ACADEMIC PERSPECTIVES

美国华裔教授学者协会学术期刊



USA CHINESE SCHOLARS ASSOCIATION

Los Angeles, California, USA, December 2025

- 美國靈芝尊** • 症狀明顯時及癌症放化療輔助: 每天早, 中, 晚飯後均可服用 • 亞健康: 每天早上服用1~2粒 • 保健: 每天早上服用1粒。
- 特效養肝素** • 症狀明顯時: 每天早, 晚飯後各服用2粒 • 亞健康: 每天晚上服用1~2粒 • 保健: 每天晚上服用1粒。
- 特效前列通** • 症狀明顯時: 每天早, 中, 晚飯後均可服用 • 7-30天後每天早, 晚飯後各服用1~2粒 • 保健: 每天1次, 服用1~2粒。
- 特效眼明素** • 症狀明顯時: 每天早, 中, 晚飯後均可服用 • 30天後每天早, 晚飯後各服用1~2粒 • 保健: 每天1次, 服用1~2粒。
- 美國蟲草至尊** • 初次服用者: 每天早上服用2粒, 連續服用35天 • 保健: 第36天開始, 每天早上服用1粒 • 男性在特殊需要時, 請於當天晚上加服2粒。
- 美國心腦康** • 症狀明顯時: 每天早, 中, 晚飯後均可服用 • 30天後每天早, 晚飯後各服用1~2粒 • 保健: 每天1次, 服用1~2粒。
- 美國強骨質素** • 症狀明顯時: 每天早, 中, 晚飯後均可服用 • 30天後每天早, 晚飯後各服用1~2粒 • 保健: 每天1次, 服用1~2粒。
- 美國金智商** • 2歲至5歲兒童: 每天1次, 服用1~2粒 • 5歲至18歲兒童: 每天2次, 每次服用1~2粒 • 成人: 每天2次, 每次服用2粒。
- 糖尿穩定素** • 症狀明顯時: 每天早, 中, 晚飯後各服用2粒 • 亞健康: 每天早, 晚飯後各服用1~2粒 • 保健: 每天服用1~2粒。
- 純天然補腎** • 症狀明顯時: 每天早, 中, 晚飯後各服用2粒 • 亞健康: 每天早, 晚飯後各服用1~2粒 • 保健: 每天服用1~2粒。
- 高純度羊胎素 (多功能, 加強型, 4合1)** • 養顏美容, 男女都適合: 每天早上空腹服用2粒, 助於祛斑, 美白, 增加皮膚彈性 • 更年期症狀時: 每天3次, 每次2粒, 視症狀情況, 可酌情增減用量。
- 美國煙清素** • 症狀明顯時: 每天早, 中, 晚飯後各服用2粒 • 亞健康: 每天早, 晚飯後各服用1~2粒 • 保健: 每天1次, 服用1~2粒。
- 抗癌先鋒199** • 癌症及放化療輔助時: 每天早, 中, 晚飯後均可服用 • 90天後每天早, 晚飯後各服用1~2粒 • 保健: 每天1次, 服用1~2粒。
- 排毒祛脂茶** • 每天飯後配合1杯8oz的熱水沖泡一杯, 適合溫度時飲用。
• 可根據自己的飲食習慣適量增減, 如喜食肉類食物或在餐館用餐時, 可以增加沖泡量 • 一般保健建議每天沖泡一杯即可。
- 口服美白素** • 每天早上空腹服用2粒 **最高峰健乳素** • 每天早, 中, 晚飯前服用1-2粒 **更年清平衡素** • 每天1-3次, 每次2粒。
- 美國NMN** • 亞健康: 每天1~2次, 每次2粒 • 保健: 每天相同時間服用一次即可。 **騰龍強力素** • 每次1~2粒。



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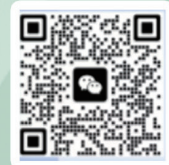


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李永田 / Yongtian Li, M.D.
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阿尔茨海默病治疗药物的最新进展

Latest Advances in Pharmacotherapies for Alzheimer's Disease

刘西平 / Xiping Liu

ConjuChem, Culver City, CA 90230, USA

摘要

阿尔茨海默病 (Alzheimer's disease, AD) 是全球最常见的慢性神经退行性疾病，也是导致痴呆的首要原因，其临床特征表现为进行性的记忆减退、认知功能下降及行为异常，对患者及社会造成沉重负担。近年来，随着研究的深入，人们对其发病机制的认识不断拓展，核心病理过程主要包括 β -淀粉样蛋白 ($A\beta$) 聚集、tau 蛋白异常磷酸化、神经炎症以及线粒体功能障碍。然而，传统对症治疗仅能带来有限且短暂的临床获益，无法逆转或延缓疾病进程。自 2021 年以来，美国食品药品监督管理局 (FDA) 已相继批准阿杜卡奴单抗 (aducanumab)、仑卡奈单抗 (lecanemab) 和多奈单抗 (donanemab) 三种 $A\beta$ 靶向单克隆抗体，标志着 AD 治疗正式迈入“疾病修饰疗法 (disease-modifying therapies, DMTs)”新时代。与此同时，针对 tau 蛋白的治疗、免疫调控、神经保护及神经再生等多种新兴策略在临床试验中亦展现出良好前景。本文综述了 AD 药物治疗的最新进展，重点阐述其病理机制与新兴治疗策略，并对未来精准医学、多靶点干预及个体化治疗的发展趋势进行了前瞻性分析。

关键词：阿尔茨海默病；疾病修饰疗法；单克隆抗体；药物研发

ABSTRACT

Alzheimer's disease (AD) is the most common chronic neurodegenerative disorder worldwide and the leading cause of dementia. Its clinical features are characterized by progressive memory impairment, cognitive decline, and behavioral disturbances, imposing a heavy burden on patients and society. In recent years, advances in research have greatly expanded the understanding of its pathogenesis, with core pathological processes including β -amyloid ($A\beta$) aggregation, tau protein hyperphosphorylation, neuroinflammation, and mitochondrial dysfunction. However, conventional symptomatic treatments provide only limited and short-term clinical benefits, failing to reverse or delay disease progression. Since 2021, the U.S. Food and Drug Administration (FDA) has successively approved three $A\beta$ -targeting monoclonal antibodies: aducanumab, lecanemab, and donanemab—marking the official entry of AD therapy into a new era of disease-modifying therapies (DMTs). Meanwhile, emerging therapeutic strategies targeting tau protein, immune modulation, neuroprotection, and neuroregeneration have also

demonstrated promising prospects in ongoing clinical trials. This review summarizes the latest advances in pharmacological treatments for AD, with a particular focus on its pathological mechanisms and novel therapeutic strategies and provides a forward-looking analysis of future directions in precision medicine, multi-target interventions, and personalized treatment.

Keywords: Alzheimer's disease; Disease-modifying therapies; Monoclonal antibodies; Drug development

引言

阿尔茨海默病 (Alzheimer's disease, AD) 是全球最常见的痴呆类型, 占有病例的约 60–80%。根据世界卫生组织 (World Health Organization, WHO) 2023 年的统计, 全球痴呆患者已超过 5500 万例, 预计到 2050 年将增至 1.5 亿以上¹。随着人口老龄化进程的加快, AD 患病率迅速上升, 凸显了开发有效治疗和预防策略的紧迫性。目前的对症治疗药物主要包括胆碱酯酶抑制剂 (如多奈哌齐 donepezil、加兰他敏 galantamine、利凡斯的明 rivastigmine) 和 N-甲基-D-天冬氨酸 (N-methyl-D-aspartate, NMDA) 受体拮抗剂美金刚 (memantine)。这些药物可在一定程度上改善患者的认知和行为症状, 但无法阻止或逆转神经退行性病变的进展²。这一局限性导致过去二十余年间数百项临床试验未能达到主要终点, AD 新药研发一度陷入低谷³。

随着分子病理学、神经影像学 and 精准医学的进步, 人们对 AD 核心病理机制的理解进一步加深。研究表明, β -淀粉样蛋白 ($A\beta$) 的过度沉积与斑块形成、tau 蛋白异常磷酸化导致的神经纤维缠结、慢性神经炎症反应以及线粒体功能障碍, 是驱动 AD 发生与进展的关键环节⁴⁻⁶。在此基础上, 以直接干预病理级联反应为目标的“疾病修饰疗法” (disease-modifying therapies, DMTs) 逐渐兴起, 其目的不仅在于改善症状, 更在于延缓甚至阻止神经变性过程, 从而改变疾病的自然病程⁷。自 2021 年以来, 美国食品药品监督管理局 (FDA) 已相继批准多种 $A\beta$ 靶向单克隆抗体, 包括阿杜卡奴单抗 (aducanumab)、仑卡奈单抗 (lecanemab) 和多奈单抗 (donanemab)⁸⁻¹⁰。这些突破性进展不仅为患者带来新的治疗希望, 也在学术界和社会公众中引发了广泛讨论, 核心议题包括疗效的持久性、安全性、成本效益以及临床适应人群的界定问题¹¹。与此同时, 以 tau 蛋白、神经炎症通路和突触功能修复为靶点的新型疗法正不断进入临床试验, 标志着 AD 药物研发正从“单一病理假说”迈向“多机制、精准化”的新阶段^{12, 13}。

AD 病理机制的演进：从单一假说到复杂网络

阿尔茨海默病 (AD) 的病理机制研究经历了由单一假说到多通路交织的转变。早期主流观点集中于 β -淀粉样蛋白 ($A\beta$) 假说, 认为脑内 $A\beta$ 过度沉积是驱动神经退行性过程的核心环节¹⁴。然而, 过去二十余年的临床试验与基础研究表明, AD 的发生与进展并非源于单一分子或通路, 而是由多重病理过

程相互作用形成的复杂网络^{15,16}。这一认识的演变不仅拓展了研究视野,也为多靶点联合干预的提出奠定了理论基础。

在A β 病理方面,研究焦点已从传统的斑块沉积转向可溶性寡聚体的神经毒性。越来越多证据显示,寡聚体A β 比斑块更具毒性,可直接损害突触可塑性、抑制长时程增强(LTP),并诱发线粒体功能障碍与钙稳态失衡^{17,18}。此外,A β 与脂质代谢密切相关,其在细胞膜微区中的异常沉积可扰乱胆固醇和鞘磷脂分布,进一步放大神经毒性效应¹⁹。这一转变推动了药物研发从单纯清除斑块走向靶向寡聚体清除与功能干预。

Tau蛋白病理是阿尔茨海默病的另一核心机制。正常情况下,tau蛋白通过稳定微管来维持轴突运输的完整性;当其发生异常过度磷酸化后,便会从微管上解离并聚集形成神经原纤维缠结(neurofibrillary tangles, NFTs),从而破坏神经元的结构和功能²⁰。与A β 病理相比,tau蛋白异常与认知功能衰退的相关性更为密切,被广泛认为是临床症状进展的重要预测指标²¹。更为关键的是,tau蛋白具备类朊病毒式(prion-like)的跨突触传播特性,提示其在病理负荷扩展过程中可能发挥驱动作用²²。影像学研究进一步证实,tau病理可导致默认模式网络(default mode network, DMN)及海马-前额叶环路的同步性下降,为认知障碍的发生提供了神经生物学基础²³。值得注意的是,近年来多项临床试验已开始探索抗tau单克隆抗体及小分子抑制剂的潜力,这不仅加深了对tau病理作用的理解,也为开发针对tau的疾病修饰疗法提供了新的可能性。

神经炎症已逐渐被认为是贯穿阿尔茨海默病(AD)始终的重要“放大器”。在疾病早期,活化的小胶质细胞能够清除 β -淀粉样蛋白(A β),发挥一定的神经保护作用;然而,随着病程进展,小胶质细胞的持续过度激活会导致炎症因子(如IL-1 β 、TNF- α)和自由基的大量释放,从而引发神经元损伤并放大病理负担²⁴。遗传学研究进一步证实,TREM2、CD33等与小胶质细胞功能相关的基因突变可显著增加AD的易感性,提示先天免疫通路在疾病发生中具有关键作用²⁵。与此同时,星形胶质细胞在谷氨酸稳态维持方面的功能障碍,以及少突胶质细胞髓鞘代谢异常,也可能在不同阶段加速神经退行性变²⁶。炎症反应与A β 沉积和tau异常之间相互作用,形成恶性循环,从而推动病理网络持续扩展并加快认知功能衰退²⁷。值得注意的是,近期以TREM2激动剂、CSF1R抑制剂以及抗炎小分子为代表的新兴免疫调控策略,已在早期临床试验中展现出缓解神经炎症与改善认知结局的潜力,这为炎症靶向治疗提供了新的方向,也提示未来治疗可能需要将免疫调控纳入综合干预框架。

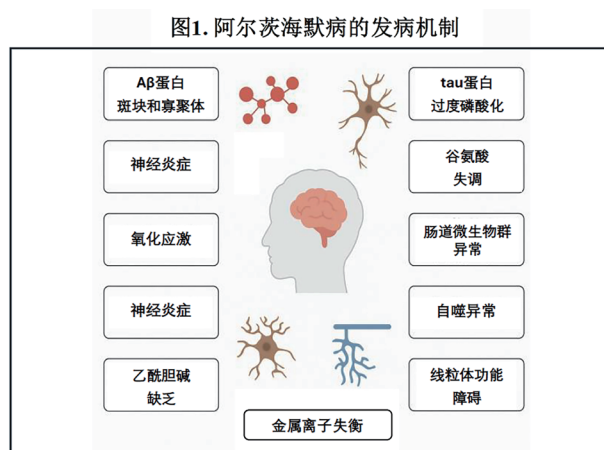
突触功能障碍被认为是阿尔茨海默病(AD)的最早期病理标志之一,甚至可能先于明显的神经元丢失而出现。大量研究表明,可溶性 β -淀粉样蛋白(A β)寡聚体能够与N-甲基-D-天冬氨酸(N-methyl-D-aspartate, NMDA)受体和 α -氨基-3-羟基-5-甲基-4-异噁唑丙酸(α -amino-3-hydroxy-5-methyl-4-isoxazole propionic acid, AMPA)受体结合,干扰谷氨酸信号传导,导致突触可塑性受损,并阻碍长时程增强(long-term potentiation, LTP)的建立,从而引发兴奋性毒性,直接破坏与学习和记忆相关的神经环路²⁸。与此同时,胆碱能系统功能的持续下降表现为乙酰胆碱合成与释放不足,导致突触传递效率减弱和神经网络协调性下降,从而进一步削弱认知加工能力²⁹。更为关键的是,抑制性中间神经元的损伤会打破谷氨酸- γ -氨基丁酸(GABA)之间的动态平衡,使神经回路处于持续过度兴奋状态,既可能引发

癫痫样放电与异常神经震荡，也会造成认知功能的波动与不稳定³⁰。近年来，神经影像学与电生理学研究进一步证实，AD患者在疾病早期即可观察到海马和皮层网络的异常过度兴奋。这一现象不仅加速了突触退化，还可能反过来促进 A β 和 tau 的异常沉积，形成恶性循环。针对突触功能障碍的干预正逐渐成为新的研究热点，例如，通过增强 GABA 能系统的抑制性神经传递、调节谷氨酸受体活性，或利用神经调控技术恢复网络稳态，均在临床前和早期临床研究中展现出一定的潜在疗效。这些发现提示，突触保护与神经网络稳态的重建，或将在未来精准干预策略中占据核心地位。

在突触异常被认为是疾病早期“起点”机制的同时，代谢与血管因素则为病程的加速与放大提供了关键驱动力。流行病学研究显示，糖尿病、肥胖和高血压等代谢-血管性疾病显著增加 AD 风险³¹。胰岛素抵抗不仅削弱了突触与线粒体的保护性信号，还使神经元对能量供应的依赖性更加脆弱；血脑屏障功能障碍则为外周炎性分子进入中枢提供通道，从而加剧神经炎症³²。与此同时，脑血流灌注不足和慢性缺血亦可进一步诱发能量代谢障碍与氧化应激，推动神经退行性病变的加速进展³³。这些代谢和血管异常不仅直接影响神经元功能，还与线粒体能量危机和氧化应激反应密切交织，为后续线粒体功能障碍的发生提供了重要背景。

值得注意的是，最新研究提示微量元素代谢可能是阿尔茨海默病早期的触发因素。2025 年 8 月 6 日发表于《自然》(Nature) 的一项研究发现，锂稳态紊乱在疾病早期即可参与病程启动，提示离子代谢失衡可能成为新的治疗切入点³⁴。未来若能结合代谢组学与神经影像学进一步阐明其作用机制，有望推动早期诊断与精准治疗策略的发展。

综上，阿尔茨海默病的病理机制已由最初的单一假说演化为多通路交织的复杂模型（图 1）。A β 、tau、神经炎症、突触功能障碍、代谢-血管异常、线粒体损伤以及系统性炎症-肠脑轴失衡等多重因素相互作用，共同驱动疾病的发生与进展。随着研究的不断深入，新机制线索不断涌现，这一认识不仅揭示了疾病的高度复杂性，也提示未来治疗必须超越单靶点模式，迈向多机制整合与精准化干预^{35, 36}。因此，从早期的对症支持到面向病理修正的药物研发转型，正是建立在这一复杂病理网络认识的基础之上。



AD 的治疗药物：从症状改善到病理修正

阿尔茨海默病 (AD) 的药物研发历程，折射出临床实践从“症状改善”逐步迈向“病理修正”的转型过程。长期以来，治疗的核心目标集中于对症干预。胆碱酯酶抑制剂（如多奈哌齐、加兰他敏和利凡斯的明）通过抑制乙酰胆碱降解，提高突触间递质水平，在一定程度上改善认知功能与日常生活能

力^{37, 38}。N - 甲基 - D - 天冬氨酸 (N-methyl-D-aspartate, NMDA) 受体拮抗剂美金刚则通过减弱谷氨酸过度活化所致的兴奋性毒性，在中重度患者中发挥认知与行为改善作用³⁹。然而，这些药物本质上仅能提供短期功能性缓解，未能直接干预驱动疾病的核心病理环节，因此无法阻止认知功能的持续下滑。单纯依赖对症治疗，已逐渐被认为难以改变 AD 的自然进程。

进入 21 世纪第二个十年，随着病理机制研究的不断深化，研究者的关注点逐步转向疾病修正治疗 (disease-modifying therapy, DMT)。其核心理念是在病程早期，即 β - 淀粉样蛋白 ($A\beta$) 沉积和 tau 蛋白异常尚未引发不可逆神经损伤之前，通过精准干预延缓甚至阻断神经退行性变，从而减缓认知功能下降的速度⁴⁰。以 $A\beta$ 假说为基础，一系列单克隆抗体药物相继进入研发前沿。阿杜卡奴单抗 (Aducanumab) 可选择性结合 $A\beta$ 寡聚体和纤维，激活小胶质细胞介导的免疫清除机制⁴¹。尽管 III 期临床试验结果存在争议，仅部分亚组患者显示认知减缓趋势，但 FDA 仍于 2021 年通过加速审批程序批准其上市，成为首个抗 $A\beta$ 的 DMT⁴²。

随后，仑卡奈单抗 (Lecanemab) 在 2022 年 Clarity AD 试验中证实可延缓认知下降 27%，并于 2023 年获批上市⁴³；多奈单抗 (Donanemab) 则在 2024 年 TRAILBLAZER-ALZ 2 研究中显示可延缓早期患者认知衰退约 35%，并在部分病例中使 $A\beta$ 负荷接近正常水平⁴⁴。这些成果不仅证明了早期 $A\beta$ 清除策略的临床价值，也极大提升了药物研发的信心。

更为重要的是，抗体药物的给药方式和安全性正在得到优化。2025 年 8 月 7 日发表于《科学》(Science) 的一项研究报道了一种基于转铁蛋白受体 (transferrin receptor, TfR) 介导的抗 β - 淀粉样蛋白 ($A\beta$) 抗体跨血脑屏障 (blood-brain barrier, BBB) 递送策略，显著提高了脑内药物的分布效率，并有效降低了与免疫治疗相关的影像学异常 (amyloid-related imaging abnormalities, ARIA) 及脑血管炎症风险⁴⁵。这一突破不仅优化了单克隆抗体的安全性与可及性，也为未来开发更多能够跨越 BBB 的生物制剂提供了全新范式。

与此同时，针对 tau 蛋白异常和神经炎症的创新策略也在快速推进。抗 tau 单克隆抗体 (如司莫瑞单抗, Semorinemab)、TREM2 激动剂以及 CSF1R 抑制剂均已进入早期临床试验，显示出延缓病理传播和调节免疫微环境的潜力^{46, 47}。在代谢调控领域，GLP-1 受体激动剂 (如司美格鲁肽, Semaglutide) 以及鼻喷胰岛素在临床前研究中展现出神经保护与抗炎效应，为探索代谢疾病与 AD 之间的病理联系提供了新的突破口⁴⁸。

天然产物的药物化探索同样展现出新势头。二氢杨梅素 (Dihydromyricetin, DHM)，一种源自藤茶的天然黄酮类化合物，兼具抗氧化、抗炎及 GABA 受体调控作用。在 AD 动物模型中，DHM 能显著改善 $A\beta$ 诱导的认知障碍，降低氧化应激水平并恢复突触可塑性⁴⁹⁻⁵¹。其作用机制不仅涉及直接清除自由基和减少淀粉样毒性，还通过增强 GABA 能系统的抑制性调节，恢复神经环路的兴奋 - 抑制平衡，从而改善学习和记忆功能⁵²。这一特性提示，调控 GABA 能神经传递可能成为未来 AD 精准干预的重要方向。

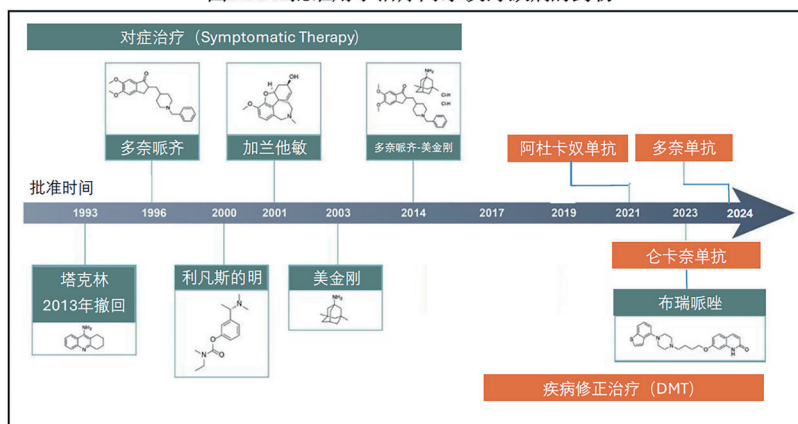
此外，免疫系统的作用正受到越来越多的关注。近年来的研究发现，外周免疫细胞，尤其是自然杀伤细胞 (natural killer cells, NKcells)，在 AD 的免疫监视与炎症调节中具有潜在作用。临床研究显示

AD 患者外周血 NK 细胞比例和活化状态发生显著改变，这不仅可能影响 A β 和 tau 的清除效率，也可能参与神经炎症的放大过程^{53,54}。如何通过免疫检查点、细胞因子调节或外周免疫细胞的再编程来改善 NK 细胞功能，成为未来 AD 免疫疗法研究的重要方向。

总体而言，AD 药物研发已逐步完成从“短期功能改善”到“长期病程修正”的转型（图 2）。对症治疗仍是临床管理的重要支撑，但真正具备改变病程潜力的干预措施正在不断涌现。未来的发展趋势将更加突出“早期精准干预”

与“多靶点协同作用”的价值，并通过遗传学、影像学与体液标志物实现个体化分层治疗。可以预见，AD 药物研发的下一个阶段将从“单靶突破”全面迈向“网络调控”，不仅反映了病理机制研究的纵深推进，也预示着精准医学理念将在神经退行性疾病领域全面落地⁵⁵。

图2.FDA批准用于治疗阿尔茨海默病的药物



AD 的未来策略：从早期干预到精准医疗

根据美国政府临床试验注册数据库 (ClinicalTrials.gov) 的最新统计，截至 2024 年底，全球范围内共有 14 种 I 期、34 种 II 期以及 11 种 III 期在研药物，覆盖了从分子靶点发现、作用机制验证到临床疗效评估的完整研发链条⁵⁶。其中部分候选药物有望在 2028 年前后完成关键性试验并获批上市，从而进一步充实疾病修正治疗的药物储备。这一趋势表明，AD 药物研发正逐渐步入“管线多元化”与“转化加速化”的新阶段。

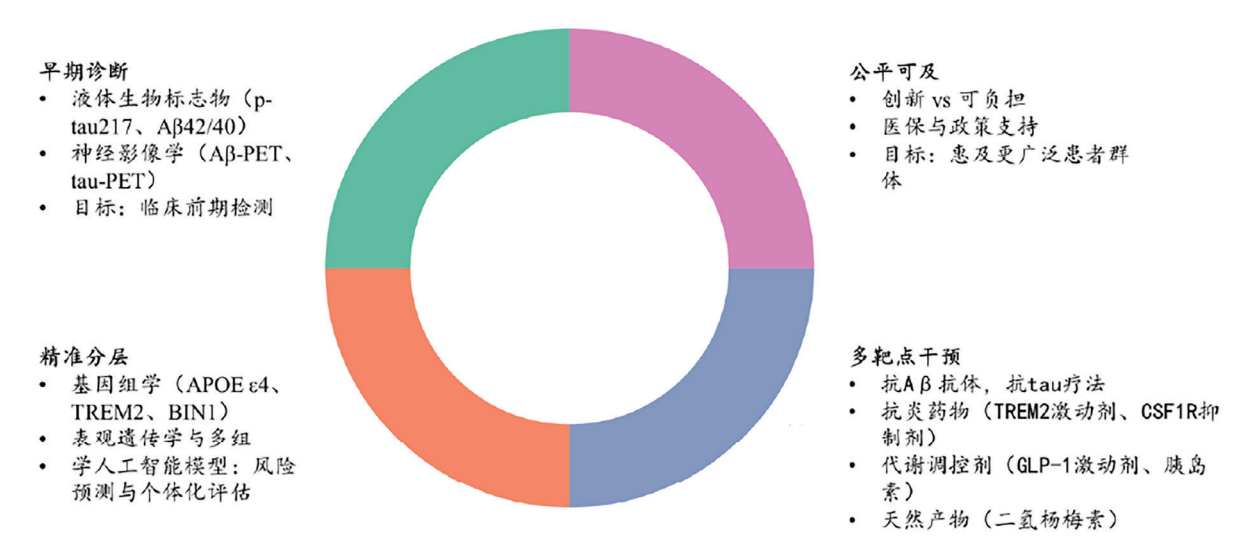
未来的治疗方向愈加突出“早期干预”的价值。越来越多的病理学与流行病学证据表明，AD 的核心病理事件包括 β -淀粉样蛋白沉积、tau 蛋白异常磷酸化以及神经炎症反应通常在临床症状出现前十年至二十年便已启动。因此，在疾病的临床前期阶段实现高效筛查与精准识别，已成为扭转病程的关键。近年来，基于血浆 p-tau217 以及 A β 42/40 比值的液体活检方法不断取得进展，其敏感性与特异性已逐渐接近 PET 成像的诊断水平。与此同时，A β -PET 与 tau-PET 等影像学技术正在临床应用中展现出对病理负担进行量化评估与动态监测的独特优势。进一步结合多组学数据与人工智能模型所构建的纵向风险预测体系，为未来的早期诊断和分层干预提供了坚实的技术支撑。

然而，AD 的病理网络极其复杂，仅依赖单一机制药物往往难以取得突破性疗效。近年来多项 III 期临床试验的失败正反映了这一困境，也促使学界逐渐达成共识：多靶点联合干预可能是未来更具前景的路径。例如，抗 A β 抗体若能与 tau 靶向治疗及抗炎小分子药物联合应用，可能在减少淀粉样斑块、抑制神经纤维缠结形成及降低神经炎症方面实现协同效应。与此同时，基因治疗、代谢调控剂以及天然

产物的整合应用也在探索之列，这类跨机制的联合策略有望在多重病理环节上发挥作用，从而显著延缓甚至部分逆转疾病进程。

在这一背景下，精准医疗的理念正在迅速落地。随着基因组学与表观遗传学的进展，研究者开始更加重视不同患者群体之间的遗传学差异。例如，APOE ϵ 4 等风险等位基因的携带者不仅具有更高的发病风险，还在免疫治疗和代谢干预的应答性上表现出异质性。此外，TREM2、BIN1 等与神经炎症和脂质代谢相关的基因位点，正逐渐成为未来患者分层与治疗决策的重要标记。这意味着未来的 DMT 研发不再局限于“普适性疗法”，而将更加依赖个体化的基因背景与分子分型，以实现精准干预。

图3. AD 的未来策略示意图



总体来看，AD 的未来治疗格局正朝着系统化与多维化方向演进（图 3）。从早期诊断与筛查，到个体化分层干预，再到多靶点联合治疗与成本可及性的保障，整个过程不仅依赖科研与临床的持续突破，也需要公共政策、伦理规范与社会共识的共同推动。唯有在多方协同下，AD 的精准防治才能真正实现从理论走向实践，从实验室走向临床，从少数人群走向大众患者。

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揭开社会隔离与阿尔茨海默症的面纱

Unmasking the Silent Trigger: How Social Isolation Fuels Alzheimer's Disease

Amy S. Shao¹ and Jing Liang²

¹*Internal Medicine & Psychiatry, Walter Reed National Military Medical Center, Bethesda, Maryland, USA;* ²*Titus Family Department of Clinical Pharmacy, Alfred E. Mann School of Pharmacy and Pharmaceutical Sciences, University of Southern California, Los Angeles, CA, USA*

ABSTRACT

Alzheimer's disease (AD) remains a therapeutic challenge, with limited success due to gaps in understanding its progression and inadequate preclinical models. Social isolation (SI), a well-documented risk factor that increases AD likelihood by 50%, has been underexplored as a primary driver of disease pathogenesis. The impacts of social distancing and loneliness on human life encompass a range of interconnected mechanisms. Social isolation and loneliness can lead to adverse effects on mental health, including increased levels of stress, anxiety, and depression, along with cognitive decline and difficulties in emotional regulation. These factors, in turn, can contribute to behavioral changes, such as disrupted sleep patterns and decreased physical activity, further impacting physical health. Additionally, social distancing and loneliness can strain social skills and relationships, leading to a diminished quality of life characterized by reduced social connections and overall well-being. Addressing these impacts requires holistic approaches that prioritize mental health support, foster social connections, and promote healthy lifestyle behaviors to mitigate the negative consequences of social isolation and loneliness.

INTRODUCTION

Alzheimer's disease (AD), the most common form of dementia, is characterized by progressive cognitive impairment, memory loss, and neurodegeneration. Despite decades of research, effective treatments remain elusive. Traditional models focused on amyloid- β and tau pathology have failed to yield substantial clinical success. Emerging evidence highlights social isolation (SI) and loneliness as major modifiable risk factors for AD, yet they remain poorly addressed in research and therapeutic design.

SOCIAL ISOLATION: A POTENT AND UNDERESTIMATED RISK FACTOR

The National Academies of Sciences, Engineering, and Medicine report that social isolation increases the risk of dementia by approximately 50%¹. Loneliness has also been linked to increased stress, depression, anxiety, and systemic inflammation, all of which are implicated in AD pathogenesis^{2,3}. SI is particularly

relevant in the context of the COVID-19 pandemic, during which rates of isolation sharply increased, exacerbating mental and cognitive health outcomes globally.

MECHANISTIC LINKS BETWEEN SOCIAL ISOLATION AND AD

- **Stress and Neuroinflammation:** SI induces chronic stress responses via the HPA axis, resulting in elevated cortisol, hippocampal atrophy, and neuroinflammation.
- **Emotional Dysregulation:** Reduced social contact impairs emotional regulation, which correlates with poor cognitive outcomes.
- **Astrocyte and Microglia Dysfunction:** Recent findings show SI leads to astrocyte atrophy and microglial overactivation, disrupting the tripartite synapse and impairing GABAergic transmission⁴.
- **Synaptic Plasticity and Gephyrin Loss:** SI reduces gephyrin, a scaffolding protein essential for inhibitory synapse integrity, contributing to impaired cognition.

Figure 1 shows a schematic summary of social isolation-induced changes in synaptic, glial, and behavioral domains leading to cognitive decline and AD.

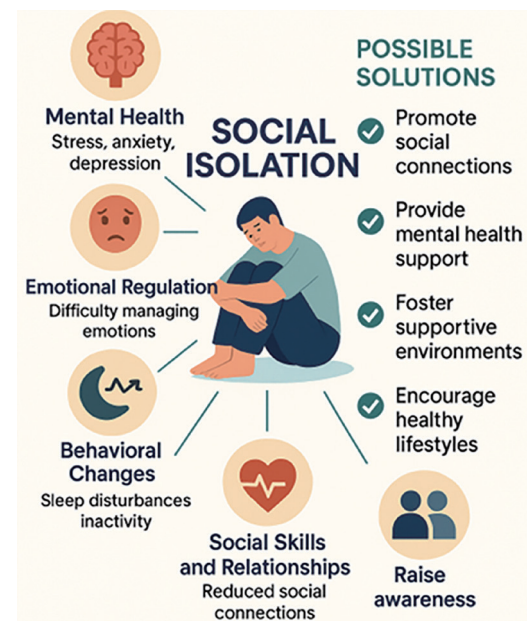


Figure 1. Social isolation and its multifaceted impacts on health and cognition.

ANIMAL MODELS REFLECTING HUMAN SI CONDITIONS

Our laboratory developed a minimally invasive SI mouse model using C57BL/6 mice. The model mimics human SI without genetic modification and demonstrates progressive anxiety-like behavior, aggression, cognitive deficits, astrocyte shrinkage, increased phosphorylated tau (pTau), and reduced gephyrin levels⁴. This model parallels the pathology of AD transgenic models.

Figure 2: Comparative histological and behavioral data from SI-exposed mice showing cognitive impairment and altered astrocyte morphology.

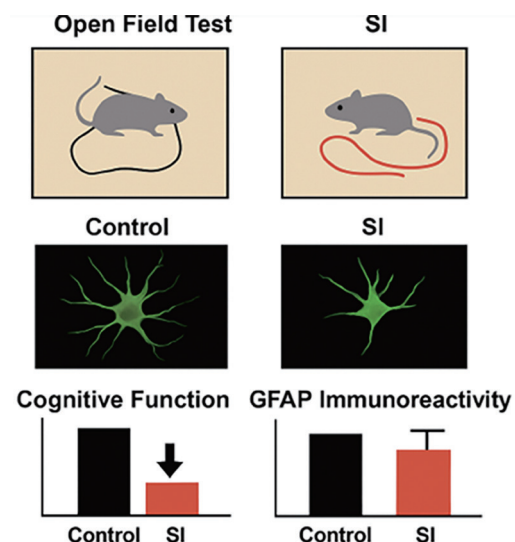


Figure 2. Comparative histological and behavioral data from SI-exposed mice.

HUMAN EVIDENCE AND EPIDEMIOLOGICAL CORRELATES

- Loneliness correlates with higher incidence of mild cognitive impairment and AD ⁶.
- COVID-19 era data show even 10 days of isolation may trigger psychiatric symptoms persisting for years ⁵.
- Imaging studies report cortical thinning and hippocampal volume loss in individuals with chronic loneliness ⁷.

PROPOSED INTERVENTIONS AND PREVENTIVE MEASURES

- Virtual and Community-Based Social Engagement: Online platforms and community centers can provide accessible interaction opportunities.
- Mental Health Services: Access to cognitive behavioral therapy (CBT) and telehealth support.
- Lifestyle Interventions: Encouraging physical activity, healthy diet, and sleep hygiene can buffer SI effects.
- Policy-Level Actions: Healthcare systems and urban planning must consider loneliness reduction as a health priority.

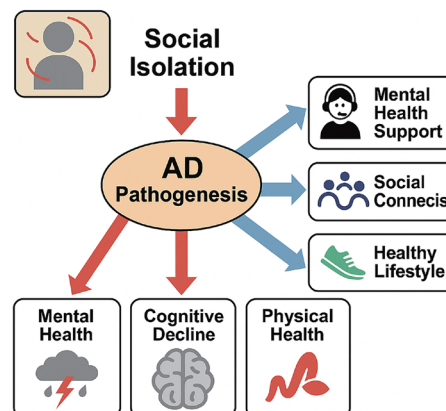


Figure 3. Proposed model integrating SI-induced pathophysiology and multimodal interventions for AD prevention.

CONCLUSION

Social isolation is not merely a psychological issue but a pathophysiological driver of cognitive decline and AD. A paradigm shift is needed in AD research and prevention strategies to incorporate SI as a central risk factor. With better models and public health initiatives, it is possible to mitigate the effects of social isolation and improve cognitive aging outcomes.

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肺炎的病理与解剖揭示传统中医肺经及肺脏的分子本质与途径

Pathophysiology and Anatomy of COVID-19 Pneumonia Reveal the Molecular Essence and Pathway of Lung Meridian and Lung Organ in Traditional Chinese Medicine

马胜兴 / Sheng-Xing Ma

Lundquist Institute for Biomedical Innovation at Harbor-University of California at Los Angeles (UCLA) Medical Center and Department of Obstetrics and Gynecology, David Geffen School of Medicine at UCLA and Harbor-UCLA Medical Center, Torrance, CA 90502

ABSTRACT

The meridian systems are believed to be physical pathways that deal with physiological regulation and pathological changes of the human body in traditional Chinese medicine (TCM) but the biomolecule mechanisms of meridians and interactions between somatic meridians and internal viscera/organs are unexplored. The new coronavirus (COVID-19) enters human tissues and organs by binding to human angiotensin-converting enzyme 2 (ACE-2) protein, causing damage to the lungs and vascular system. ACE2 is the main entry receptor for the new coronavirus, and drugs that close ACE2 channels in lung and intestinal organoids can prevent viral infection. Based on TCM, meridians are the pathways for the transmission of pathogenic factors, and defending the body while ACE2 is the main entry receptor for the new coronavirus from the outside into the lungs through the nose, throat, and trachea. Another important physiological function of the lungs in TCM is to regulate water channels, and the renin-angiotensin system plays a very important role in regulating water metabolism. Angiotensin I needs to form active angiotensin II under the action of converting enzyme (ACE) of pulmonary angiogenesis, resulting in vasoconstriction, water and sodium retention, and inflammatory response. ACE2 and ACE have opposite effects. The new coronavirus binds to the ACE-2 receptor to downregulate the ACE-2 receptor, which causes an increase in angiotensin II activity, subsequently, resulting in hypertension,

Corresponding author: Sheng-Xing Ma, Ph.D., Professor, Lundquist Institute for Biomedical Innovation at Harbor-UCLA Medical Center, 1124 W. Carson Street, E6-room 219, Torrance, CA 90502. Tel: (310) 974-9573; E-mail: sxma@lundquist.org.

thrombosis, arrhythmia, and inflammatory reactions. The new coronavirus binds to the ACE-2 receptor and enters vascular endothelial cells, affecting the production of nitric oxide (NO) and causing damage to the vascular system. Endogenous NO deficiency and endothelial dysfunction contribute to the infection and development of the new coronavirus. The pathophysiology and anatomy of COVID-19 pneumonia reveal that ACE and ACE2 are the pathways through which the pathogenic factors of COVID-19 are transmitted, and have the function of regulating water metabolism, and highly expressed in pulmonary vascular and all vascular endothelial cells with nitric oxide over the body as the Lung viscera leading all blood vessels in the body. These characteristics should be attributed to further study that ACE and ACE2 are the biomolecules of the lung meridian in TCM and participate in the organ functions of lung.

Keywords: Angiotensin-converting enzyme; COVID-19; nitric oxide; regulating water metabolism; lung viscera in traditional Chinese medicine; meridian substances

INTRODUCTION

The meridian systems, as described by traditional Chinese medicine (TCM), play important roles in the connection from the surface of the body to the internal viscera/organs and communication with the universe, environment, and our body as a whole, which contribute to transmission of pathogens, and defending the body by resisting external evils and invasion (Wang *et al.*, 2010; Zhu and Hao, 1989). The theory of viscera-organs in TCM includes the physiological functions of human viscera and meridian systems, their external appearance and relationships with physiological regulation each other and with the external environment and pathological changes since meridians circulate “meridian qi,” evoking dynamic processes such as energy exchange, moisten and nourish viscera, organs, and tissues. However, the pathway structures, biomolecules, and functions of the meridians based on biomedical sciences are still unknown (Wang *et al.*, 2010; Zhu and Hao, 1989; Chan 1984)). One of the 125 major exploration and discovery questions is that “Is there a scientific basis to the meridian system in traditional Chinese medicine?” as the international frontier, global common needs and gathering foresight released in 2021 by Shanghai Jiao Tong University and Science magazine (Levine 2021). Over the last few decades, there are various studies from different international groups have demonstrated some of the specificity for the acupoints and/or median lines in the body and generally accepted several meridian phenomena with commonly observed and internationally identified as: 1) the characteristics of low electrical resistance and high electric conductance of acupoints/meridians; 2) the propagated sensation (numbness, pressure, heaviness, warmth, and/or radiating paresthesia from the subjects) along meridian pathways (PSCP) induced by local stimulations of distal acupoints in the same meridian; and 3) radioactive or fluorescent tracers along a linear path resembling acupoints and meridians (Ma 2021, 2024a, 2024b). A review article summarized that L-arginine-derived NO synthesis and noradrenergic transmission modify skin electric conductance, which contributes to low resistance characteristics of acupoints and meridians (one of the meridian phenomena) (Ma 2021). For the scientific explaining PSCP phenomena, a recent review demonstrated that the stimuli-evoked axon reflex and NOergic biomolecules/neuropeptides over acupoints one after another along the median lines, which increases local blood flow and somatosensory signal transduction for PSCP perceptions in the skin and subcutaneous tissue under a linear path resembling acupoints and meridians through the gracile nucleus-thalamic-cortex pathways (Ma 2024a). The evidence and understanding of the biomolecular processes of the tracers along a linear pathways resembling meridians have been explained that NO-cGMP and

neuropeptides mediating stimuli-evoked axon reflexes increase local blood flow with higher levels in acupoints/meridians which move radioactive substances or tracer dyes in the skin and subcutaneous tissue contributing to tracers along linear pathways resembling meridians in another review (Ma 2024b). However, the most logical and direct approach to identify a specialized anatomic entity and biomolecules of the connection and interrelationship between somatic meridian and viscera/organ are still lack (Levine 2021; Ma 2021, 2024a, 2024b).

Based on TCM, acupuncture points (acupoints) are located along the 12 main somatic meridian pathways, and each somatic meridian connects its specific internal organ (viscera), and superficial organs and tissues (Wang *et al.*, 2010; Zhu and Hao, 1989). The system can be viewed as a complex dynamic system and somatic-organ interaction for physiological regulation and pathological changes. The research on TCM has failed to achieve a major breakthrough because the fundamental concept such as the physiological functions of the viscera and the meridian system can be viewed as a complex holistic dynamic system and interaction/connection between somatic meridian and viscera/organ. The new coronavirus (COVID-19) has been tormenting the human world for the past three years. During these days of fighting against viruses, people have gradually discovered that COVID-19 is not a simple “pneumonia” (Del and Malani, 2020; Ahn *et al.*, 2020). The increased interest in the pathways for the invasion and transmission of COVID-19 and the disease influence on specific physiological regulation and pathological changes (Wu *et al.*, 2020; Wadman *et al.*, 2020; Hoffmann *et al.*, 2020), which has led to an open-minded attitude towards understanding the molecular essence of Lung meridian and lung organ in TCM. It is fundamental important to establish the valid aspects of scientific basis and mechanisms of the somatic-internal organ interaction. The evidence and understanding of the pathophysiology and anatomy of COVID-19 pneumonia researches have been summarized with an emphasis on the developments of the pathways for the invasion and transmission of this new coronavirus through Lung meridians and the physiological regulation of metabolic balance of water fluid and the influence on vascular endothelial cells over the body during the disease processes for lung organ of TCM in this review.

ACE2 IS THE MAIN ENTRY RECEPTOR FOR THE INVASION AND TRANSMISSION OF COVID-19 PNEUMONIA REFLECTING THAT ACE2 IS THE LUNG MERIDIAN SUBSTANCE, AS MERIDIAN IS THE PATHWAY FOR THE INVASION AND TRANSMISSION OF PATHOGENS IN TCM

According to TCM, there are 12 main somatic meridian pathways, and each somatic meridian connects its specific internal viscera, which regulate the physiological functions and reflect the pathological changes of internal organs (Wang *et al.*, 2010; Zhu and Hao, 1989). Meridians can circulate qi, blood, yin and yang, and play a role in resisting external evils and protecting the body. In pathological conditions, meridians are also the pathways for the transmission of pathogenic factors. When the body surface is invaded by pathogenic factors, the meridians can pass from the surface to the inside, from superficial to deep, and gradually inward, affecting the internal organs, or from one internal organ to another organ. The main physiological functions of the Lung viscera described in TCM are: dominating qi of respiration and the whole body, dominating descending and regulating water passage, dominating dispersing, skin and hair, and opening into the nose. However, modern biological studies have failed to define evidence and pathways of lung in the circulation and excretion of water and transmission of pathogenic factors as well as the close physiological relationships between lung, nose, skin and hair. In a pathological state, the meridian is also the channel for transmission of pathogenic factors (Wang *et al.*, 2010; Zhu and Hao, 1989). When the body surface is invaded by pathogenic factors, it can pass through the meridians from the surface to the interior, from the shallower to the deeper, and gradually spread to the internal organs, or spread to the viscera as well as from one viscera into another organ. For example, wind-cold

external pathogens invade the surface of the skin, and at the beginning, fever, aversion to cold, head and body pain occur due to the combination of the lung and skin-fur. If the external pathogens are incomprehensible, the pathogens can spread to the lungs internally, and symptoms such as cough, chest pain, and dyspnea appear.¹ The most common symptoms of acute COVID-19 infection are fever, chills, shortness of breath, myalgia, headache, anosmia, dysgeusia, cough, and infections in trachea and lung, which belong to the disease in viscera lung and Lung meridian in TCM (Wu *et al.*, 2020; Wadman *et al.*, 2020; Hoffmann *et al.*, 2020). The high contagiousness of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) cause person-to-person transmission directly through respiratory droplets during sneezing or coughing or indirectly through contaminated surfaces (Wadman *et al.*, 2020)

The novel coronavirus binds to human angiotensin-converting enzyme 2 (ACE-2) protein enters human tissues, organs and vascular endothelial cells, causing damage to the lungs and vascular system (Hoffmann *et al.*, 2020). Experimental evidence showed that the new coronavirus mainly achieves infection through the combination of its surface spike protein and the ACE2 receptor on human cells (Hoffmann *et al.*, 2020; Kuba *et al.*, 2005). The spike protein is the protein that the new coronavirus uses to recognize host cells and is also the main target of the human immune system. Clinical and experimental studies have demonstrated that ACE2 is constitutively expressed and released from the apical cell surface of human airway epithelia into airway surface liquid while the airway and lung are the main targets of the new coronavirus (Hoffmann *et al.*, 2020; Kuba *et al.*, 2005; Jia *et al.*, 2009). Downregulation of ACE2 protein expression has been shown in an in vitro system (cell lines) and also in vivo in lung cells of mice, which suggest that ACE2 pathway may produce protective effects following infection (Jia *et al.*, 2009; Imai *et al.*, 2005). Based on TCM, The meridians through which diseases and pathogens invade and transmit changes, and play a role in resisting external evils and defending the body. Under pathological conditions, meridians are also responsible for the transmission of pathogenic factors. When the body surface is invaded by pathogenic factors, it can pass through the meridians from the surface to the inside, from shallow to deep, and gradually spread to the inside to affect the internal organs, or from one internal organ to another internal organ (Wang *et al.*, 2010; Zhu and Hao, 1989). For example, wind and cold external evils invade the muscles. Externally, fever, chills, head and body pain, etc. are initially seen. Over time, the external evils will spread internally to the lungs, causing symptoms such as cough, chest pain, and dyspnea.

Because the epithelium of the nasal cavity, throat, trachea, and alveoli is rich in containing ACE-2 receptors (Jia *et al.*, 2009; Imai *et al.*, 2005; Gheblawi *et al.*, 2020), the virus enters human tissues and organs through the nasal cavity, throat, trachea, and alveoli cause inflammation of the respiratory tract and lungs. It appears that ACE2 is the main entry receptor for the new coronavirus to enter the lungs from the outside, through the nose, throat, and trachea, which should belong to the Lung meridian substances since meridian is the pathway for the invasion and transmission of pathogens described in TCM (Wang *et al.*, 2010; Zhu and Hao, 1989). In addition, drugs that close ACE2 channels in lung organoids and intestinal organoids can prevent the progression of viral infection, revealing the meridian-dependent properties of ACE-2 (Jia *et al.*, 2009; Imai *et al.*, 2005; Gheblawi *et al.*, 2020). ACE2 pathway also produce protective effects by downregulation of ACE2 protein expression following infection. These evidences further support that ACE2 is the Lung meridian substance for the invasion of the new coronavirus and transmission of the pathogens during COVID-19 infection.

ACE AND ACE2 ARE REGULATORS OF THE RENIN-ANGIOTENSIN SYSTEM DEMONSTRATING THAT THEY ARE THE LUNG MERIDIAN SUBSTANCES AS LUNG VISCERA IN TCM REGULATES THE METABOLISM OF WATER FLUID

One of the important physiological functions of Lung organ in TCM is the water channel, that is, the lungs have the effects of regulating, promoting and maintaining the metabolic balance of water fluid. For a long time, the scientific community has been unable to use modern physiological knowledge to explain the theory of Lung viscera in TCM with metabolism of water fluid. Although respiratory function to be genuine evidence as similar functional existence between Lung viscera in TCM and modern biomedical sciences, there is a gap for understanding the physiological functions of Lung viscera in TCM in regulating, promoting and maintaining the metabolic balance of water fluid. The chemicals, anatomy, and mechanisms of the Lung viscera in TCM for metabolism of water fluid are unknown (Wang *et al.*, 2010, Ma 2021, 2024a, 2024b).

In the last few decades, the discoveries of new peptides and volume-sodium physiology have increased our understanding the complexity of the renin-angiotensin system (RAS), which comprises three significant components: renin, angiotensin II, and aldosterone as a complex hormonal pathway that is a critical regulator of blood volume, electrolyte balance, and systemic vascular resistance (Gheblawi *et al.*, 2020; Kanugula *et al.*, 2023). These new peptides form a counter-regulatory pathway of the RAS, and cross-talk between the two main pathways and their receptors (Kanugula *et al.*, 2023; Wu *et al.*, 2018; Santos *et al.*, 2018). Angiotensinogen is a 485 amino acid alpha 2-globulin primarily synthesized and constitutively secreted by the liver and renin, which is secreted in the kidney, cleaves this molecule leading to the formation of angiotensin I (Ang 1-10) (Danser and Deinum, 2005). Angiotensin-Converting Enzyme 1 (ACE1), which is expressed on plasma membranes of vascular endothelial cells, mainly in pulmonary circulation, cleaves the two amino acids from the dipeptide Ang I to make the Angiotensin II (Ang II 1-8) (Studdy *et al.*, 1983; Falkenhahn *et al.*, 1995). Ang II is the primary mediator of the physiological effects of RAS, including volume regulation, blood pressure, and aldosterone secretion (Guo *et al.*, 2001), and is implicated in many pathophysiological states, which is known to induce oxidative stress, vascular smooth muscle contraction, endothelial dysfunction, fibrosis, and hypertrophic, anti-apoptotic, and pro-mitogenic effects (Mehta and Griendling, 2007; Rajagopalan *et al.*, 1996; Dzau 2001). The pathogenesis of hypertension, atherosclerotic disease, heart failure, obesity-mediated hypertension, and kidney disease have been implicated through these effects of Ang II (Schieffer *et al.*, 2000; Ferrario 2006).

The discovery of Angiotensin-Converting Enzyme 2 (ACE2) was first reported in 2000 (Donoghue *et al.*, 2000), and progressively developed as a counter-regulatory (protective) pathway for the regulations of metabolism of water fluid including blood volume, electrolyte balance, and vascular resistance. Two substrates of ACE2 in the RAS are Ang I (1-10) (Donoghue *et al.*, 2000), and Ang II (1-8) (Patel *et al.*, 2016; 2017). ACE2 converts Ang I (1-10) to Ang (1-9) and Ang II (1-8) to Angiotensin (1-7). The catalytic efficiency of ACE2 is 300 times higher for Ang II than Ang I (Vickers *et al.*, 2002). ACE2 is mainly expressed in the lungs and also shown in cardiovascular system, kidneys, adipose tissue, and brain (Gembardt *et al.*, 2005; Hamming *et al.*, 2004; Paizis *et al.*, 2005). A significant amount of surface expression of ACE2 on lung alveolar epithelial cells and enterocytes of the small intestine (Hamming *et al.*, 2004), which helped us understand the tissue distribution and disease pathogenesis. Ang II (1-9) causes blood pressure reduction and reduces hypertension-induced cardiovascular and renal inflammation through different mechanisms like vasodilation and natriuresis (Ocaranza *et al.*, 2014; V *et al.*, 2020; Gonzalez *et al.*, 2018). Ang (1-7) has multiple biological activities opposing Ang II (1-8) actions and induces anti-inflammatory, vasodilatory, antiangiogenic, antihypertensive, and antifibrotic effects (Mercure *et al.*, 2008; Oudit and Penninger, 2011; Touyz and Montezano, 2018).

ACE1 and ACE2 are two zinc metalloproteases involved in the biogenesis of the components of renin-angiotensin system (RAS) (Danser and Deinum, 2005; Studdy *et al.*, 1983; Falkenhahn *et al.*, 1995). Angiotensin I must form active angiotensin II under the action of the converting enzyme (ACE1) required for pulmonary vasculogenesis resulting in vasoconstriction, water and sodium retention, and inflammatory

response (Danser and Deinum, 2005; Studdy *et al.*, 1983; Falkenhahn *et al.*, 1995). ACE2 processes angiotensin (Ang) I and II into Ang (1–9) and Ang (1–7), respectively, which are known to mediate vasodilative (hypotension), antiproliferative and apoptotic effects opposing the effects of ACE/Ang II/Ang II type 1 receptor (AT1R) pathway (Mercure *et al.*, 2008; Oudit and Penninger, 2011; Touyz and Montezano, 2018). ACE2 and ACE1 have opposite effects and serves as the Yin and Yang of ACE/ACE2 Pathways for regulating water and salt metabolism (Zamai 2020). The recent studies of the new coronal virus have further demonstrated that the binding of the new coronal virus and ACE-2 receptor to reduce the ACE-2 activity causes the vitality of vascular tension to enhance the vitality, and produces hypertension, thrombosis, arrhythmia, and inflammatory response.13-17 Interestingly, ACE1 is produced by pulmonary blood vessels (Studdy *et al.*, 1983; Falkenhahn *et al.*, 1995), and ACE2 are highly expressed in lung epithelial cells.36-38 The levels of ACE2, which is positively correlated with airway epithelial differentiation. ACE and ACE2 mainly distribute in the lung and are regulators of the renin-angiotensin system, which support the TCM theory “Lung viscera regulates the metabolism of water fluid”. These studies agree with the functions of Lung viscera in TCM and further suggest that ACE/ACE2 and related peptides, Ang II (1-8), Ang II (1-9) and Ang (1-7), are biochemical molecules in the Lung viscera and meridians for physiological regulation of the metabolism of water fluid and the pathological changes during diseases. This is another evidence suggesting that ACE/ACE2 and related peptides, Ang II (1-8), Ang II (1-9) and Ang (1-7), are the Lung meridian substances, which contribute to regulation and metabolism of water fluid described as one of the important functions of Lung viscera in TCM.

ACE and ACE2 that are highly expressed in pulmonary vascular and all vascular endothelial cells with nitric oxide (NO) over the body further confirms that ACE and ACE2 are the Lung meridian substances as the Lung viscera leads all blood vessels in the body (Convergence of all vessels in Lung viscera) in TCM

One of another important physiological functions of lung viscera in TCM is that the all blood vessels within the body converge to the Lung viscera (the Lung viscera leads all blood vessels) or all blood within the body must pass through the Lung viscera (Wang *et al.*, 2010; Zhu and Hao, 1989). During the studies of COVID-19 infection, it is well-documented that COVID-19 virus enters the vascular endothelial cells by combining human ACE-2 protein, causing damage to the whole vascular system. Because the vascular endothelial cells are spread all over the whole body, the new coronary virus may invade various organs after entering the human body. It is believed that the disease of the new crown is not a simple infection, because a large amount of data shows that the disease is involved in the probability of stroke, thrombosis, and other various cardiovascular diseases (Hoffmann *et al.*, 2020; Wadman *et al.*, 2020). The clinical presentation of COVID-19 begins with acute respiratory distress in the lungs that moves quickly to vascular networks throughout the gut, kidney, heart, brain and skin with associated endothelial dysfunction (ED) and abnormally rapid life-threatening blood clotting (Schieffer *et al.*, 2000; Ferrario 2006).

It is believed that Covid-19 is emerging as a thrombotic and vascular disease targeting endothelial cells throughout the body and is particularly evident in patients with cardiac metabolic comorbidities associated with ED (Schieffer *et al.*, 2000; Donoghue *et al.*, 2000). Since the endothelium releases nitric oxide (NO) as the vasodilator and antithrombotic factor, whereas NO is impaired in injured vessels, contributes to hypertension and thrombus formation (Ferrario 2006). Obviously, ACE and ACE2 are biomolecules within pulmonary blood vessels and pulmonary epithelial cells that have fluxing water channels and lead all blood vessels (all over the body's vascular endothelial cells) (Zamai *et al.*, 2020). Experiments show that the combination of new coronal virus and ACE-2 receptor enters the human vascular endothelial cells, which affects the production of NO, causing destruction to the vascular system, endogenous NO deficiency and ED.

It is well-documented that NO is one of the most important messenger molecules, and NO stimulates guanylyl cyclase to generate cGMP, a second messenger directing vasodilatation (Denninger and Marletta,

1999). Intrinsic vasodilator action of NO-cGMP is critical important in microvascular endothelial function (MEF) and serves as a surrogate index of MEF (Quyyumi 1998; Moncada and Higgs, 1991). ED contributed to various cardiovascular disorders including essential hypertension, coronary artery disease, and thrombus formation (Cai and Harrison, 2000; McLenachan *et al.*, 1990). A hallmark of ED with thrombotic events is the suppression of endothelial NO synthase (eNOS) with concomitant NO deficiency. It is suggested that restoring NO, independent of eNOS, may counter endothelitis and contribute to pulmonary vasodilation, antithrombotic, and direct antiviral activity (Martel *et al.*, 2020; Green 2020; Varga *et al.*, 2020). Moreover, NO has been demonstrated to interfere with the interaction between coronavirus viral S-protein and its cognate host receptor, ACE-2, while NO-mediated S-nitrosylation of viral cysteine proteases and host serine protease, TMPRSS2, which are both critical in viral cellular entry, appear to be NO sensitive (Akerstrom *et al.*, 2009; Hoffman *et al.*, 2020).

CONCLUSION AND FUTURE PERSPECTIVE

There has been a widespread and increasing interest in scientific examinations exploring the Meridian System and the use of acupuncture for treatment of disorders over the world. However, the most logical and direct approach to identify a specialized anatomic entity and biomolecules of somatic meridian and viscera/organ are still lack. The chemicals, structure, functions and mechanisms of the meridians are unclear. The function of meridians in TCM is essential in regulation of the environmental balance as an organic whole by circulating the vital energy and blood, and connecting the internal organs with superficial organs and tissues. The COVID-19 epidemic is spreading all over the world, and the etiological agent of COVID-19 has been confirmed as SARS-CoV-2. ACE2 has a variety of physiological effects: negative regulation factor for nephrotin-vascular tension system, promoters of amino acid transportation, and SARS-COV-2 receptors. ACE2 is the receptor and transmission pathway for the new coronavirus to enter the human body. The new coronavirus binds to the ACE-2 receptor to downregulate the ACE-2 receptor, causing the activity of angiotensin II to increase, resulting in hypertension, thrombosis, arrhythmia, and inflammatory reactions. ACE1 and ACE2 are produced by pulmonary blood vessels and lung epithelial cells and have the function of regulating water and salt metabolism. The new coronavirus binds to the ACE-2 receptor and enters human vascular endothelial cells, affecting the production of NO and causing damage to the vascular system.

The experimental results from pathophysiology and anatomy of COVID-19 pneumonia reveal that ACE and ACE2 are the pathways through which the pathogenic factors of COVID-19 are transmitted, and have the function of regulating water metabolism. The main results and new findings in these studies are: 1) Transmission of pathogenic factors: ACE2 is the receptor for the new coronavirus to enter the human body and the pathway for the transmission of pathogenic factors; 2) Resist external evils and protect the body; 3) ACE and ACE2 are produced by the lungs and have the function of regulating water and salt metabolism, and angiotensin I must form active angiotensin II under the action of the ACE of pulmonary angiogenesis, resulting in vasoconstriction, water and sodium retention, and inflammatory response; 4) Highly expressed in pulmonary vascular and all vascular endothelial cells with NO over the body further confirms that ACE and ACE2 are the Lung meridian substances as the Lung viscera leads all blood vessels in the body (The lungs move toward the hundred vessels) in TCM. These characteristics should be attributed to the substances of the lung meridian in TCM and participate in the organ functions of lung. A more sophisticated approach with direct experiments would be required to address this issue. Despite these limitations, these new findings enable to generate a novel hypothesis that the new coronary virus pneumonia's pathophysiosity, physiological reconciliation and solution, revealing that ACE and ACE2 are biomolecules that serve as transmission of pathogenic factors in the lung,

resisting external evils and protect the body, regulating water and salt metabolism, and highly expressed in pulmonary vascular and all vascular endothelial cells with NO over the body as the Lung viscera leading all blood vessels in the body. These current progresses have made it dissolved into the theory of TCM to establish a scientific basis of the hypothesis that ACE and ACE2 are the biomolecules of the lung meridian in TCM and participate in the organ functions of the lung. These new findings and hypothesis undergird the theoretical and logistic foundation for future studies. The increased interest in the meridian system and organ functions based on TCM theory have led to an open-minded attitude towards understanding this system, which will bring groundbreaking results not only into the TCM but also physiological regulation and the pathophysiology of clinical disorders in biomedical sciences.

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癌症免疫治疗：挑战与突破

Cancer Immunotherapy: Challenges and Breakthroughs

李永田 / Yongtian Li

国际生物医学科学学会
International Association of Biomedical Sciences (IABS)

摘要

癌症免疫治疗已成为肿瘤学领域最具前景的治疗策略之一，为先前难以治愈的恶性肿瘤患者带来了持久的缓解。然而，该领域仍面临诸多挑战，包括免疫抵抗、肿瘤异质性、治疗相关毒性以及肿瘤微环境的复杂性。本综述全面总结了近期在以下四个主要领域的进展与挑战：核酸和疫苗类免疫治疗、细胞与基因工程方法、肿瘤微环境与免疫调节、以及转化与临床见解。核酸技术（如 mRNA 疫苗和 RNA 纳米粒子）通过高特异性靶向和多重功能负载显著提升了治疗效果，特别是在个性化癌症疫苗方面。细胞疗法（如 CAR-T 细胞和 CRISPR 基因编辑）在血液肿瘤中取得突破，但实体瘤的治疗仍受限于抗原异质性和微环境抑制。肿瘤微环境通过调节性免疫细胞和代谢竞争等机制限制免疫反应，而免疫检查点抑制剂和新靶点（如 CD47-SIRP α 轴）的开发为克服这些障碍提供了新途径。此外，系统生物学、人工智能和微生物群研究正在推动个体化治疗的发展。本文是基于 2024 年 12 月份国际生物医学科学学会举办的年会总结，旨在提供肿瘤免疫疗法的全面视角，最新进展和挑战，以促进对肿瘤免疫疗法的认知和下一代癌症免疫治疗的创新。

ABSTRACT

Cancer immunotherapy has become one of the most promising strategies in oncology, yielding durable remissions in previously refractory malignancies. However, significant barriers remain, including immune resistance, tumor heterogeneity, toxicity, and the complexity of the tumor microenvironment. This review synthesizes recent progress and ongoing challenges across four major domains: nucleic acid and vaccine-based immunotherapies; cellular and genetic engineering approaches; tumor microenvironment and immune modulation; and translational/clinical insights.

Keywords: Cancer, Immunotherapy; Nucleic Acid; mRNA Vaccine; Cancer Vaccines; Engineered T Cells; Tumor Microenvironment; Immune Checkpoint Inhibitors; CAR-T Cells; Gene Editing; Nanoparticles

INTRODUCTION

Cancer immunotherapy represents a paradigm shift in the management of both solid and hematological malignancies. By leveraging the body's immune system to identify and destroy cancer cells, immunotherapies have produced responses that are unprecedented in terms of durability and potential for cure. The success of immune checkpoint inhibitors, CAR T cell therapy, and mRNA vaccines has demonstrated the power of this approach. Nonetheless, the majority of patients do not achieve lasting remission, and immune-related adverse events, primary and secondary resistance, and the immunosuppressive tumor microenvironment remain major barriers.

A comprehensive understanding of the complex interplay between cancer cells and the host immune system is essential for the development of more effective treatments. Advances in genomics, synthetic biology, nanotechnology, and computational science have all contributed to a rapidly evolving field. This review organizes recent progress and challenges into four major categories, aiming to provide a critical overview for researchers and clinicians involved in the next generation of cancer immunotherapy.

NUCLEIC ACID AND VACCINE-BASED IMMUNOTHERAPIES

Recent years have witnessed remarkable advances in the application of nucleic acid technologies to cancer immunotherapy. The development of RNA nanoparticles has enabled a new class of therapeutics that can target tumors with high specificity, reduced systemic toxicity, and the ability to carry multiple payloads^{1,2}. The programmable nature of RNA molecules allows for the creation of particles with controlled size, structure, and surface characteristics, which can be further modified with tumor-targeting ligands or antibodies.

The rapid translation of mRNA vaccine platforms from infectious disease to oncology has transformed the landscape of cancer vaccines^{3,4}. mRNA vaccines are advantageous due to their rapid, scalable manufacturing, ability to encode any antigen of interest, and strong induction of both cellular and humoral immunity. Personalized mRNA vaccines, which encode patient-specific neoantigens, have shown promising results in early clinical trials. These vaccines are often delivered via lipid nanoparticles or other nanocarriers, improving delivery to antigen-presenting cells and enhancing immune activation.

Despite the potential, challenges persist. RNA is inherently unstable and prone to rapid degradation *in vivo*. Chemical modification of RNA bases, optimized formulations, and nanoparticle encapsulation are required to improve stability and delivery⁵. Immunogenicity is a double-edged sword: while strong immune responses are desired, excessive innate activation or autoimmunity must be avoided⁶. Clinical experience has shown that mRNA vaccines can be safe and well tolerated, though rare immune-related adverse events do occur.

Cancer vaccines—whether peptide, protein, DNA, RNA, or vector-based—aim to prime the immune system against tumor-associated antigens (TAAs) or tumor-specific neoantigens^{7,8}. Several strategies are now under clinical investigation: viral vectors encoding tumor antigens, personalized neoantigen vaccines, and whole-cell or dendritic cell vaccines. Systems biology approaches, including high-throughput sequencing, single-cell profiling, and multi-omics, are increasingly used to identify immunogenic targets and predict patient responses⁹.

An emerging frontier is the use of live-attenuated bacteria and oncolytic viruses as both antigen delivery vehicles and immune stimulants¹⁰. The integration of systems medicine—analyzing interactions among genomics, proteomics, immune cell subsets, and the tumor microenvironment—has begun to inform vaccine design, combination therapy selection, and prediction of resistance mechanisms.

Efficient delivery of nucleic acid therapeutics remains a central challenge¹¹. Nanoparticles, exosomes, lipid-based carriers, and other synthetic vesicles are in development to enhance tumor targeting, cellular uptake, and endosomal escape. Advances in click chemistry and surface engineering have enabled the creation of multifunctional nanoparticles capable of carrying siRNA, miRNA, mRNA, or even small-molecule drugs^{12, 13}. Preclinical studies have shown that rationally designed RNA nanoparticles can accumulate in tumors within minutes and are rapidly cleared if not tumor-bound, minimizing toxicity.

Clinical translation is ongoing, with multiple nanoparticle-based delivery systems now in phase I/II trials for solid and hematologic malignancies¹⁴. Key barriers include scale-up for manufacturing, reproducibility, regulatory approval, and the management of potential immune or off-target toxicities. The future of cancer immunotherapy will likely feature combination approaches that integrate mRNA vaccines, gene editing, and nanotechnology-based delivery for highly individualized patient treatment.

CELLULAR AND GENETIC ENGINEERING APPROACHES

The genetic modification of immune cells has led to some of the most striking successes in cancer immunotherapy¹⁵. Engineered T cells, including chimeric antigen receptor (CAR) T cells and T cell receptor (TCR) transgenic T cells, have revolutionized treatment for certain hematologic cancers and are now being adapted for solid tumors. CRISPR/Cas9 and other gene-editing platforms allow precise editing of genes involved in antigen recognition, costimulation, exhaustion, and immune evasion^{16, 17}.

CRISPR-based genome editing has been used to disrupt immune checkpoint genes, remove endogenous TCRs to reduce graft-versus-host disease, and insert synthetic receptors for improved specificity¹⁸. Preclinical and early-phase clinical studies have demonstrated the safety and feasibility of CRISPR-edited T cells in humans. Further improvements in delivery methods, off-target risk assessment, and in vivo gene-editing technologies are ongoing¹⁹.

CAR T cell therapy has produced remarkable clinical responses in patients with relapsed or refractory B cell malignancies, leading to several FDA-approved products^{20, 21}. The clinical success in leukemia and lymphoma has spurred efforts to expand this modality to other cancers. In solid tumors, CAR T therapy faces unique challenges: tumor antigen heterogeneity, limited infiltration, immunosuppressive microenvironments, and risk of on-target, off-tumor toxicity^{22, 23}.

Strategies to overcome these include local or regional delivery of CAR T cells, engineering of new costimulatory domains, and the use of “armored” CAR T cells co-expressing cytokines or checkpoint inhibitors. Combination therapies with immune checkpoint blockade, targeted therapies, or radiation are under investigation to enhance persistence and efficacy²⁴.

Natural killer (NK) cells and stem cell-derived cytotoxic cells represent emerging frontiers in adoptive cell therapy^{25, 26}. NK cells can lyse tumor cells without prior sensitization and are less likely to cause graft-versus-host disease. Genetic engineering of NK cells, such as the knockout of inhibitory receptors, has shown to enhance anti-tumor activity and enable “off-the-shelf” therapies with broad applicability. Human pluripotent stem cells (hPSCs) can now be differentiated into immune effectors and engineered for improved persistence and function, creating a scalable source for allogeneic cell therapy.

Despite dramatic responses, relapse after CAR T cell or TCR therapy is common²⁷. Mechanisms include antigen loss, poor CAR T persistence, emergence of resistant tumor clones, and suppression by regulatory cells or myeloid-derived suppressor cells (MDSCs). High-dimensional immune profiling, single-cell sequencing, and multi-omics are now used to monitor therapy response and guide next-generation modifications^{28, 29}.

TUMOR MICROENVIRONMENT AND IMMUNE MODULATION

The tumor microenvironment (TME) is a dynamic, heterogeneous milieu comprising cancer cells, immune cells, stromal cells, vasculature, extracellular matrix, and various soluble factors³⁰. The interplay among these elements has a profound influence on tumor progression, immune evasion, and therapeutic response.

The infiltration and function of regulatory immune cells, particularly T regulatory cells (Tregs), myeloid-derived suppressor cells (MDSCs), and tumor-associated macrophages (TAMs), are key mechanisms by which tumors suppress anti-tumor immunity^{31, 32}. Immune checkpoint inhibitors (ICIs) have shown durable responses in subsets of patients, but overall response rates remain limited³³. The identification and targeting of immune checkpoints on phagocytic cells, such as the CD47-SIRP α axis, represent a novel dimension of immunomodulation that can potentiate macrophage-mediated tumor clearance³⁴.

Macrophages constitute a major fraction of immune cells in tumors³⁵. Their role is complex, as they can be polarized into tumor-promoting (M2-like) or tumoricidal (M1-like) phenotypes. Therapies targeting these signals, such as anti-CD47 antibodies, have demonstrated preclinical and early clinical activity.

Tumor cells and immunosuppressive cells in the TME often exploit intracellular signaling networks to resist immune attack. SUMOylation, metabolic competition, and hypoxia all play crucial roles in immune evasion³⁶. Physical interventions—such as low-level laser therapy or mild local hyperthermia—can reprogram the metabolic state of tumors and immune cells, enhancing infiltration and function of cytotoxic lymphocytes.

Beyond the local TME, the systemic immune system and host environmental factors—including the gut microbiome—have emerged as crucial determinants of immunotherapy response. Microbial diversity and composition can modulate systemic inflammation and the risk of immune-related adverse events³⁷. Interventions to modulate the microbiome, such as fecal microbiota transplantation, are under investigation.

AI-based technologies and microfluidics are rapidly advancing the capacity to personalize immunotherapy and adapt interventions in real time based on dynamic patient responses^{38, 39}.

TRANSLATIONAL AND CLINICAL INSIGHTS

Psychological health and environmental stressors can impact the efficacy of cancer immunotherapy⁴⁰. Emotional distress and elevated stress hormones may suppress anti-tumor immune responses. Integrative care models that address psychological wellbeing are important components of cancer management.

The translation of novel immunotherapies from bench to bedside is subject to rigorous regulatory evaluation⁴¹. Real-world evidence, including post-marketing surveillance and registry data, is increasingly important in refining risk-benefit profiles.

SUMMARY

Cancer immunotherapy has evolved from a promising concept to a cornerstone of modern oncology, enabling unprecedented responses in multiple cancer types. The rapid progress in nucleic acid nanotechnologies, mRNA vaccines, and engineered cell therapies has demonstrated the power of harnessing and reprogramming the immune system. Simultaneously, a deeper understanding of the tumor microenvironment, metabolic crosstalk, and systemic host factors has revealed both new therapeutic opportunities and complex challenges, including resistance, toxicity, and patient heterogeneity.

Multimodal and combination approaches—uniting advances in RNA and gene editing, immune checkpoint blockade, cellular engineering, and metabolic modulation—are showing synergistic benefits in both

preclinical and clinical studies. Emerging fields such as microbiome engineering, artificial intelligence-guided therapy, and novel delivery technologies promise to individualize and optimize treatment. Yet, durable cures for most solid tumors remain elusive, with immune escape and tumor evolution continuing to drive relapse in many patients.

Future success will depend on integrative research and clinical translation, bringing together molecular, cellular, microenvironmental, and psychosocial understanding. Only through such holistic approaches—supported by robust real-world evidence, patient-reported outcomes, and equitable global access—will the full promise of cancer immunotherapy be realized for all patients.

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通过结合两种互补空气净化器 降低病房颗粒物、细菌和流感病毒的有效性

Reducing the Effectiveness of Ward Particulate Matter, Bacteria and Influenza Virus by Combining Two Complementary Air Purifiers

Bingliang Zhou^{1,†}, Tiantian Liu^{2,†}, Siqu Yi³, Yuanyuan Huang¹, Yubing Guo³, Si Huang³,
Chengxing Zhou¹, Rong Zhou^{3,*} and Hong Cao^{1,*}

¹Guangdong Provincial Key Laboratory of Tropical Disease Research, Department of Microbiology, School of Public Health, Southern Medical University, Guangzhou 510515, China; ²School of Public Health, Guangdong Pharmaceutical University, Guangzhou 510310, China; ³State Key Laboratory of Respiratory Disease, National Clinical Research Center for Respiratory Disease, Guangzhou Institute of Respiratory Health, First Affiliated Hospital of Guangzhou Medical University, Guangzhou Medical University, Guangzhou 510180, China

ABSTRACT

Air purifiers should pay much attention to hospital-associated infections, but the role of a single air purifier is limited. The goal of this study was to evaluate the effectiveness of the combined application of the nonequilibrium positive and negative oxygen ion purifier (PNOI) and the high-efficiency particulate air filter (HEPA) on a complex, polluted environment. Two of the better performing purifiers were selected before the study. The efficacy of their use alone and in combination for purification of cigarette particulate matter (PM), *Staphylococcus albicans*, and influenza virus were then evaluated under a simulated contaminated ward. PNAI and HEPA alone are deficient. However, when they were combined, they achieved 98.44%, 99.75%, and 100% 30 min purification rates for cigarette PM, *S. albus*, and influenza virus, respectively. The purification of pollution of various particle sizes and positions was optimized and reduced differentials, and a subset of airborne influenza viruses is inactivated. Furthermore, they were superior to ultraviolet disinfection for microbial purification in air. This work demonstrates the strong purification capability of the combined application of these two air purifiers for complex air pollution, which provides a new idea for infection control in medical institutions.

Keywords: combined application; air purifier; purification rate; particulate matter; *Staphylococcus albus*; influenza virus

INTRODUCTION

Since 2019, the world has remained torn by the novel coronavirus, and it is undeniable that it allows us to recognize that hospital-associated infection (HAI) control remains inadequate in healthcare settings today. In the early stage of the COVID-19 epidemic, among 138 hospitalized patients with COVID-19 in a hospital in Wuhan, China, 41% of them were suspected to be related to hospital transmission¹. In a major London teaching hospital, 66/435 (15%) of COVID-19 inpatient cases between 2 March and 12 April 2020 were definitely or probably hospital-acquired through varied transmission routes². Between March 2020 and February 2021, 185 (8.6%) cases were considered cases of nosocomial transmission in a tertiary university hospital in the city of Sao Paulo, Brazil³. Of course, the reality is far more than these, exposing the severity of HAI as early as 2002 with severe acute respiratory syndrome coronavirus (SARS-CoV)⁴ and in 2012 with Middle East respiratory syndrome coronavirus (MERS-CoV)⁵. Nearly 1.7 million hospitalized patients in the United States are simultaneously infected with HAI every year, of which more than 98,000 patients die of HAI⁶. Clearly, the hazards of HAI were identified many years ago, but the control of HAI remains a difficult problem in current healthcare systems⁷.

Due to the particularities of the hospital, its environment contains a large number of microorganisms⁸, and it provides very favorable conditions for the reproduction and spread of pathogenic microorganisms^{9, 10}. On the other hand, as a major site of antibiotic use, HAI and antimicrobial resistance mutually promote the formation of a vicious cycle^{11, 12}. There is strong evidence that airborne and aerosol transmission of pathogenic microorganisms are widespread in hospital environments¹³. In addition to this, several meteorological factors influence the survival and spread of nosocomial environmental pathogens, such as inappropriate air filtration and recirculation that can exacerbate virus spread on wards and other adjoining spaces (i.e., corridors)¹⁴. The higher relative humidity may lengthen the survival time of the new corona virus in the air¹⁵. The increase in temperature facilitates the multiplication of microorganisms in the ward environment¹⁶, and patients and medical staff act as vectors of infection between medical institutions¹⁷. This means that, without protection, the nosocomial population is consistently exposed to a multiple infection risk¹⁸.

To improve HAI status, traditional views have focused on strategies to eliminate pathogens present on patients, clinical surfaces, and health care workers¹⁹, which has prompted the implementation of various infection control and disinfection protocols that have also been successful in reducing the incidence of HAI²⁰. However, recent studies have shown that a significant proportion of pollutants causing infections in the human population are airborne^{13, 21}. Improving health care expenditure and reducing hospital air pollution can effectively reduce the mortality rate of SARS-CoV-2²², and mechanical air conditioning and natural ventilation technologies have a positive effect on hospital air purification²³. Therefore, the application of various air purification technologies in hospitals has good prospects. Some studies have evaluated the HEPA cleaner and found that it reduces the average room PM2.5 concentration from 17.0 $\mu\text{g}/\text{m}^3$ to 9.26 $\mu\text{g}/\text{m}^3$ and reduces the medication burden in asthmatic children²⁴. More studies have shown that some air purification technologies are effective for a certain contaminant; for example, HEPA purifiers reduced the concentration of phiX174 bacteriophages in aerosol by 99.9974–99.9999%²⁵, HUCoV-229E was inactivated in less than 60 min on brass nanomaterials containing at least 70% copper²⁶, and so on. Visible air cleaners may have an effect on a certain contaminant in room air but are unknown for hospital wards where multiple contaminants are present. A rigorous and feasible line of research is needed in the area of air filtration and recirculation in healthcare facilities, ensuring the ability to respond to possible new outbreaks¹⁴.

To ask the purifier scheme that can cope with multiple pollutants, two air purifiers based on HEPA and nonequilibrium positive and negative oxygen ions were selected after testing multiple air purification units in

this study. We evaluated the decontamination capacity and deficiencies of their separate use and explored the combined use on different pollutants in indoor air. The study created heavily polluted environments of cigarette PM, *S. albus*, and influenza virus, and their concentrations before and after purification were detected to evaluate differences in indoor air pollutants by position, particle size, and decontamination efficacy. In addition, the findings can provide a reference for the effective application of air purification equipment in hospital wards.

MATERIALS AND METHODS

Pollutant and Experimental Equipment

S. albus standard strain 8032 (Guangdong Institute of Microbiology, Guangzhou, China), cigarettes (Hongta Mountain, Yunnan, China) and H1N1-pr8 influenza virus (obtained from internal stock) were selected as simulated indoor air pollutants in this study.

S. albus was cultured in agar medium (nutrient agar, HuanKai Microbial, Guangzhou, China). Influenza virus was inoculated and amplified in 10-day-old embryonated chicken eggs (emerging Huanong, Guangzhou, China). MDCK cells were cultured in Dulbecco's Modified Eagle medium (containing 100 U/mL penicillin, 100 µg/mL streptomycin and 10% fetal bovine serum, Shanghai Excell Bio, Shanghai, China). An ABI7500 real-time PCR machine determined the number of virus copies (Thermo Fisher Science, Waltham, MA, USA). Viral copy number was determined using an ABI7500 real-time PCR machine (Thermo Fisher Science, Waltham, MA, USA). Aerosols were generated using microbial aerosol generator (Kangjie Instrument Research Institute, Liaoyang, China). Particles were determined by Y09-301 laser dust particle counter (WeiTian Environmental Technology Co., Ltd., Suzhou, China). Bacterial aerosols were collected with FA-1 six-stage sieve hole percussive air microbial sampler (Jintan District Jincheng Shuohua instrument Factory, Figure 1), and influenza virus was collected with ZW-100 portable large flow bioaerosol sampler (Guangzhou medium and Micro Technology Co., Ltd., Guangzhou, China).

Experimental Scene

We adapted a container to model a standard ward (Figure 2). The room had an effective area of 16.0 m² and a volume of 41.6 m³. It was placed on a ground platform with less staff movement, was closed, and was less affected from the outside world. The in-house included a regular ward facility, including a bed, table, chair, locker, bathroom, washing equipment, etc. As the basic living environment for patients, the basic structure of this ward meets the standards for environmental science (Table 1). According to the sampling criteria and the indoor arrangement, we selected 7 sampling sites (A–G) in the room.

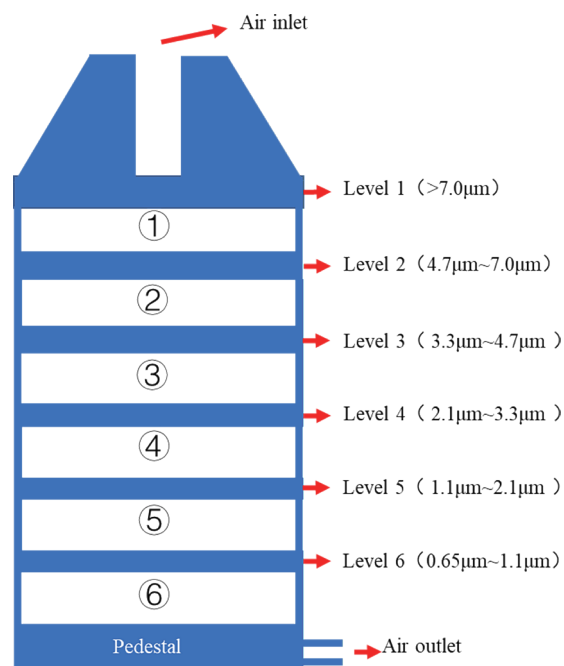


Figure 1. Structure diagram of bacterial sampler. ① - ⑥ are the places where agar plates are placed, and levels 1–6 can selectively collect aerosols with corresponding particle size.

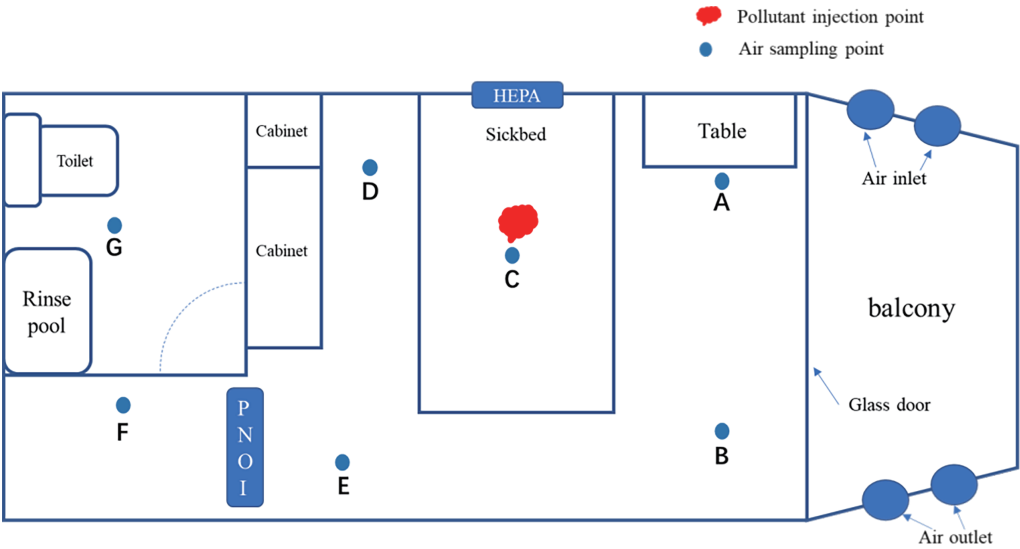


Figure 2. It contains the infrastructure of the standard ward (shown in part of the figure), pollutant injection points, and 7 (A to G) sampling positions. In addition, HEPA is installed 2 m above the head of the bed, and PNOI is installed at the central air conditioning outlet on the right side of E.

Air Purifiers

Before conducting formal experiments, we tested five kinds of air purifiers, namely, HEPA purifier, nonequilibrium positive and negative oxygen ion purifier (PNOI), negative air ion generator, photocatalyst purifier, and neowind purifier. After comprehensive analysis, the best performing HEPA and PNOI were selected. HEPA purifier uses a filter system composed of HEPA, and air contaminants in the filter are constantly blocked from the filter when it reaches between the filter trap and the fiber through a 0.024 m² vent at 1.0 m/s speed. The manufacturer declared its ability to reduce PM_{2.5} below 35 μg/m³ and to ≥99.0% purification of *S. albus* in 1 h. PNOI, which produces nonequilibrium positive and negative oxygen ions at a lower voltage, can kill planktonic bacteria in the air by collision and the redox effect of positive and negative ions, and its vents have an effective area of 0.88 m² and wind speed of 2.5 m/s. The assay reports that it is capable of killing ≥99.8% of *S. albus* in 1h. They are currently the more mainstream air purification units and are less expensive and easy to install.

Formation of Heavily Polluted Environment

Within the infectious disease ward, the contaminant was mainly generated by the patients while the patients were mostly bed-ridden, so we took the central C of the bed (Figure 2) as the point of occurrence for the contaminant. We used PBS to dissolve the *S. albus* cultured for 24 h to make the absorbance of 0.48–

Table 1. Index of indoor environment in simulation ward

Index	Actual Level
Room volume	41.62 m ³ /P
Net story height	2.61 m
Coefficient of room depth	2.21
Daylight factor	≥1.0%
Total viable count	<500 cfu/m ³
Fresh air volume	30–60 m ³ /(h·P)
PM10	<0.05 mg/m ³
Temperature	18–28 °C
Humidity	50–80%

0.51 and diluted it another 1000 times for use. The influenza virus with the PCR assay result of CT = 15–20 was selected for use. The prepared bacterial or viral fluid was added into the microbial aerosol generator and sprayed for 15 min, and the air was mixed thoroughly with a fan to form a room environment heavily contaminated with bacteria or viruses. The cigarette was directly ignited at C for 15 min, and then a heavily polluted environment with PM was formed after mixing.

Additionally, the microbial aerosol generator was continuously turned on until the end of sampling after the heavily polluted environment was formed, thus creating a continuously contaminated ward environment.

Collection and Detection of Samples

The samples for the first round were collected at each sampling site (0.5 m from the wall surface and 1.4 m from the ground surface) after the environment was stabilized. After acquisition was completed, samples were collected once each at 10, 20, and 30 min with the purifier turned on, and sampling without turning on the purifier served as a control. The bacterial samples were incubated 24 h in a bacterial incubator at a temperature of 37 °C before counting. Viral samples RNA was partially extracted and viral copy number was determined using a real-time PCR. MDCK cells were infected with the positive viral samples, and cytopathic changes were observed using an inverted microscope after one day of culture. The amount of PM can be read on-site, and the analysis can be performed when the results are saved.

Quality Control

Prior to formal experiments, we performed multiple pre-experiments with rigorous training and division of labor for experimenters. Clean clothes, hats, and shoe covers were worn during sampling to ensure that the operation of the experiment was smooth. On the other hand, UV disinfection was performed for 30 min before the experiment, and the closed standing was allowed to stand for 3 h, and a convenient dehumidifier and air conditioning were used to regulate the temperature (20–28 °C) and humidity (50–70%) in the room to ensure that the heat and humidity were relatively stable.

Data Analysis and Calculation Formula

We calculated acquired pollutant concentrations using Excel (Microsoft Office Professional Enhanced Edition 2019, Microsoft, Redmond, WA, USA) and summarized categorically. Means and standard deviations were calculated with IBM SPSS statistics 26, and *t* tests and ANOVA were performed to evaluate statistical differences among variables (ns = no significant difference, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, $\alpha = 0.05$). Plotting of graphs was performed using GraphPad prism 8.

Calculation formula for pollutant purification rate is as follows:

$$K = (C_0 - C_t) / C_0$$

K: purification rate; C₀: Initial pollutant concentration; C_t: t minute pollutant concentration.

3RESULTS

Preliminary Purification of Three Air Pollutants by Two Purifiers

Before testing the effect of the combination, we individually evaluated the efficacy of HEPA and PNOI to purify airborne PM, *S. albus*, and influenza virus. For environments heavily contaminated with PM (Figure 3), only a 55.89% average purification rate was observed after 30 min of the PNOI running, and the average

PM_{2.5} and PM₁₀ concentrations were 42.76 µg/m³ and 64.38 µg/m³, respectively. On the contrary, HEPA showed a good purification efficiency, achieving a 97.23% average purification rate at 30 min and PM_{2.5} and PM₁₀ average concentrations of 5.48 µg/m³ and 14.05 µg/m³, respectively, but the purification rate was not sufficient (10 min: 52.00%). The purification rate of *S. albus* by HEPA reached 99% in 30 min, and the number of colonies was reduced to 464.41 cfu/m³. The purification effect of the PNAI running 10 min was significantly better than that of the HEPA ($p < 0.001$), but the purification at 30 min was not significantly different from that of the HEPA ($p > 0.05$). For influenza virus, the PNOI was globally leading the HEPA in purification capacity ($p < 0.001$ at each time point) and completely purified the virus by 30 min.

After that, we turned on the two purifiers simultaneously. The purification efficiency and speed were significantly improved ($p < 0.001$), with an 86.25% purification rate at 10 min, and the average PM_{2.5} and PM₁₀ concentrations at 30 min were only 0.81 µg/m³ and 2.48 µg/m³, respectively, reaching very clean levels. For both bacteria and viruses, purification was accelerated over a short period of 10 min compared to PNOI (their purification rate at 10 min was comparable to that of a 20 min PNOI run); *S. albus* eventually decreased to 5.05 cfu/m³, and the influenza virus was completely cleared.

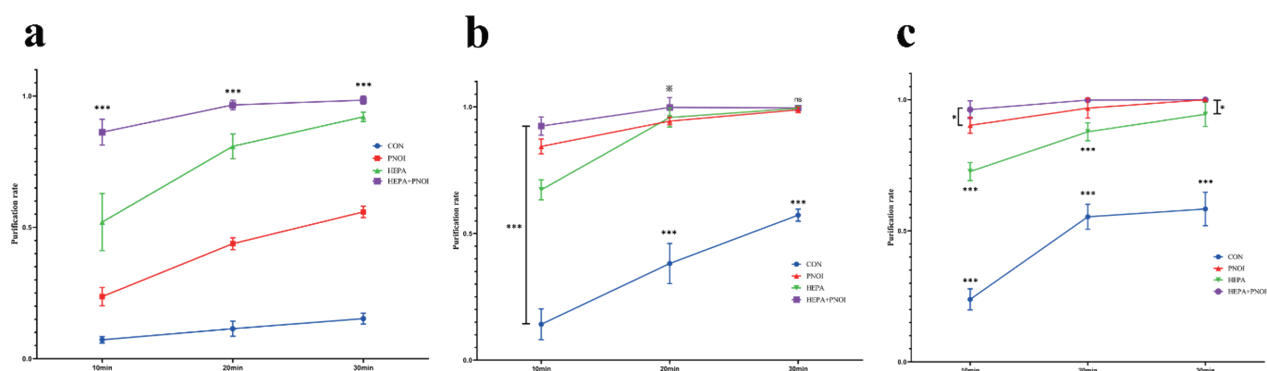


Figure 3. Purification rate of air pollutants with each module. (a) Cigarette particulate matter; (b) *S. albus*; (c) influenza virus. The statistical difference for the last time of different modules is analyzed (ns: no significance; * $p < 0.05$; *** $p < 0.001$).

Combined Application was Effective for Different Positions and Particle Sizes

After detecting the size of each of the particles and aerosols at different sites, we further analyzed the effect of the air cleaner on complex spaces and particle sizes. After the particles were purified for 30 min, the PNOI against a diameter of 0.3–0.5 µm had a significantly poorer purification effect than the other particle sizes ($p < 0.001$). Interestingly, HEPA was relatively less effective for particles larger than 5.0 µm in diameter ($p < 0.001$). Predictably, the combined application of the two purifiers had a significantly better purification effect on each particle size than did their application alone, and only the particle purification rate (88.46%) from diameter 0.3–0.5 µm was slightly lower than that of the others ($p < 0.05$). Based on the characteristics of the bacterial sampler, we measured the number of colonies contained in aerosols in six particle size ranges. At 30 min operation, PNOI had a slightly lower effect on aerosols with a diameter of 0.65–2.1 µm than other particle sizes ($p < 0.001$), while the purification rates for the combined applications showed no significant difference in particle size ($p > 0.05$), and all had good effects (Table 2).

Analyzing the different positions (Table 3), HEPA showed a slightly lower PM decontamination rate in D ($p < 0.01$). PNOI did not differ significantly across sites ($p > 0.05$) but purification was general. After the combined application, the purification rate of D was slightly lower than that of the other positions, but they were not statistically different ($p > 0.05$); meanwhile, the purification effect was also significantly better than that of the single purifier ($p < 0.001$). Unlike PM, the bacterial purification at different positions by two purifiers applied individually or in combination was excellent and showed no significant difference ($p > 0.05$).

Table 2. Six particle sizes of particles and aerosol purification rate (% , mean (SD))

Pollutant	Diameter (μm)	CON	HEPA	PNOI	HEPA + PNOI
PM	0.3–0.5	6.20 (1.41)	88.63 (2.71)	41.68 (2.55)	97.98 (0.22)
	0.5–1.0	21.67 (2.18)	94.40 (1.33)	64.88 (1.87)	98.57 (0.74)
	1.0–3.0	53.45 (1.97)	97.52 (0.52)	84.50 (0.63)	96.86 (0.52)
	3.0–5.0	7.08 (6.11)	82.74 (3.63)	65.31 (2.76)	88.46 (3.16)
	5.0–10.0	14.46 (9.76)	75.75 (4.91)	67.75 (2.86)	93.76 (2.62)
	>10.0	32.80 (7.07)	67.73 (4.22)	81.15 (2.75)	98.16 (2.93)
Bacterial aerosol	0.65–1.1	46.59 (8.76)	99.52 (0.45)	97.79 (0.70)	99.85 (0.19)
	1.1–2.1	20.97 (5.65)	99.54 (0.31)	96.92 (0.80)	99.85 (0.15)
	2.1–3.3	42.69 (3.42)	99.64 (0.26)	99.50 (0.28)	99.91 (0.11)
	3.3–4.7	72.17 (9.94)	99.52 (0.33)	99.88 (0.16)	99.93 (0.11)
	4.7–7.0	85.81 (4.05)	99.33 (0.61)	99.64 (0.42)	99.47 (0.50)
	>7.0	75.30 (6.83)	99.21 (0.75)	99.50 (0.79)	98.59 (0.28)

Combination Application Accelerates Influenza Virus Inactivation

Previous experiments used RT-PCR to test samples for influenza virus content, but viral activity could not be determined. We infected MDCK cells with virus-positive samples (Table 4) and found that both influenza viruses were active in the positive samples from HEPA (48/48), while the virus was still active in the samples from PNOI 57.50% (23/40). After the combined application, the virus activity decreased to 37.50% (12/32), of which none of the positive samples at 20 min showed activity.

Combination Application Better than Common UV Disinfection

UV disinfection is one of the best methods for indoor environment disinfection. To evaluate the difference in decontamination between common UV lamps and our purifiers, we examined the efficacy of ultraviolet lamps for *S. albus* and influenza virus using the same method (Figure 4). In contrast, it was found that there was no significant difference between bacterial purification by the combination of two purifiers and UV lamps ($p > 0.05$). For influenza virus, the average purification rate of UV disinfection was 93.43%, which could not completely purify the influenza virus in the room air at 30 min and was less effective than the purifiers combination ($p < 0.05$). In a general ward where UV lamps are inconveniently applied, it is obvious that the combination of air purifiers can replace UV lamps to play an effective air purification role.

Combination Applications Still Have Better Effects on Continuously Polluted Environments

The previous experiments evaluated the direct effect of the combination of the two cleaners and gave

Table 3. PM and aerosol purification rates at 7 positions (% , mean (SD))

Pollutant	Position	CON	HEPA	PNOI	HEPA + PNOI
PM	A	30.10 (7.30)	86.78 (8.18)	74.32 (6.03)	91.45 (7.84)
	B	32.06 (8.33)	84.82 (6.82)	74.91 (6.09)	95.73 (2.92)
	C	29.26 (5.24)	91.24 (6.85)	73.48 (6.06)	93.13 (5.99)
	D	25.44 (5.07)	79.13 (7.51)	76.37 (6.28)	88.83 (9.38)
	E	26.19 (6.24)	88.86 (9.09)	69.12 (6.12)	95.62 (5.43)
	F	30.32 (6.23)	83.42 (5.35)	67.42 (6.40)	92.04 (6.97)
	G	19.07 (8.59)	87.51 (6.27)	72.23 (6.59)	95.35 (5.04)
Bacterial aerosol	A	58.04 (4.58)	99.20 (0.50)	98.55 (0.75)	99.92 (0.12)
	B	48.98 (5.10)	99.47 (0.44)	98.45 (0.4)	99.62 (0.48)
	C	60.42 (7.68)	99.30 (0.62)	99.19 (0.71)	99.62 (0.64)
	D	58.27 (9.15)	99.58 (0.35)	99.21 (0.63)	99.86 (0.32)
	E	63.50 (5.90)	99.49 (0.33)	98.82 (0.75)	99.75 (0.32)
	F	50.39 (5.08)	99.86 (0.16)	99.12 (0.70)	100.00 (0)
	G	61.13 (5.50)	99.12 (0.59)	98.73 (0.73)	98.43 (0.29)

Table 4. Result of influenza virus activity assays

Purifier	Active	Inactive	Total	Activity Ratio (%)
CON	67	0	67	100.00
HEPA	48	0	48	100.00
PNOI	23	17	40	57.50
HEPA + PNOI	12	20	32	37.50

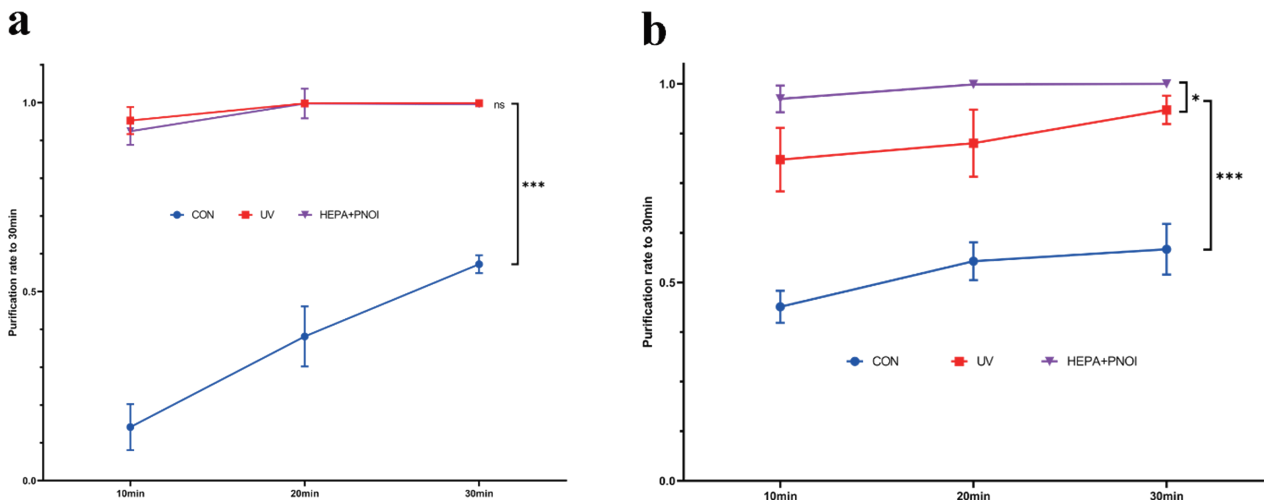


Figure 4. Comparison of the efficacy of purifier combination and UV lamps in removing *S. albus* (a) and influenza virus (b). The statistical differences between the items are analyzed. (ns: no significance; * $p < 0.05$; *** $p < 0.001$).

positive results, but because patients live for long periods of time in the hospital, the contamination of the ward is often persistent. We therefore evaluated their effects in a simulated continuously polluted environment (Figure 5). Obviously, both bacterial and viral purification effects of the continuously contaminated environment were slightly lower than those of the primary contaminated environment ($p < 0.05$), but at 30 min, the decontamination rates could both reach 90%. Their purification rates against *S. albus* continued to increase over time ($p < 0.05$), whereas those against influenza viruses stabilized at around 90%.

DISCUSSION

This study tested the purification efficacy of two air purifiers for a heavily contaminated ward environment. The purification effect of HEPA filtration technology on indoor PM and aerosols is widely recognized²⁷⁻²⁹. PNOI is based on this emerging technology of nonequilibrium positive and negative oxygen ions, and our study demonstrates a superior capability in decontaminating bacteria and viruses, with the released ions also inactivating part of airborne influenza viruses. After multifaceted analysis, we confirmed that the two purifiers combined obviously strengthened their air purification capacity and were able to effectively purify complex room air pollution for a short period of time.

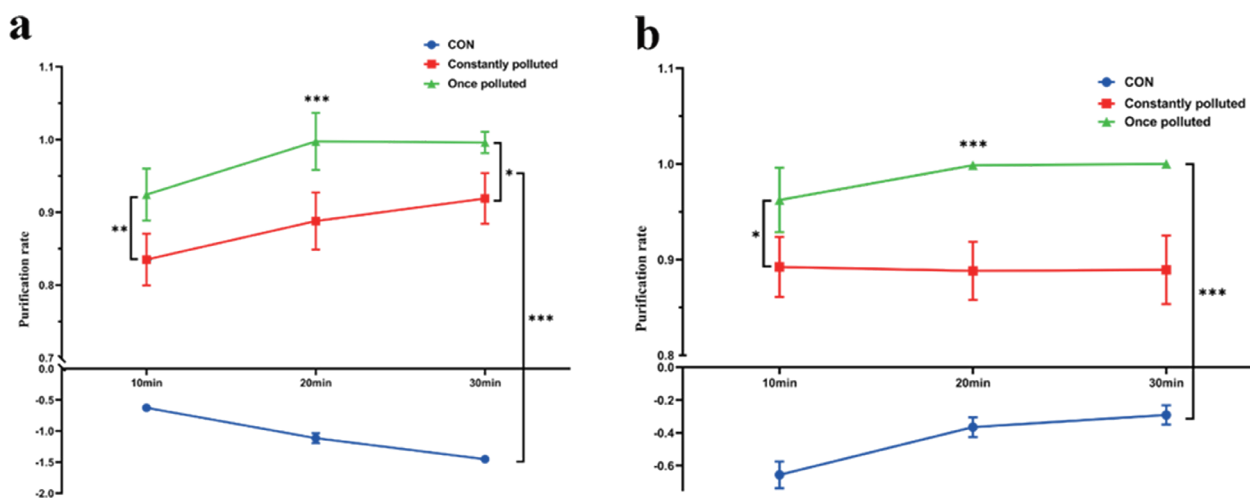


Figure 5. Comparison of the effects of combined application on the removal of *S. albus* (a) and influenza virus (b) from constantly and once-polluted environments. The statistical differences between the items are analyzed. (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

PM, as one of the most dominant pollutions in the air, i.e., fine particles with a diameter of $\leq 5 \mu\text{m}$, persists in the air for a long time and can easily enter the lower respiratory tract^{30, 31}. The small particle is orders of magnitude larger in air, and when the purifier is used, it falls far more easily than the large particles, exhibiting relatively better particulate matter purification below $5 \mu\text{m}$ in diameter, which is consistent with Dubey's findings²⁷. In addition to PM, aerosols carrying pathogenic microorganisms are ubiquitous in ward air^{9, 32}. Agarwal's study in New Delhi indicated $1.1\text{--}4.7 \mu\text{m}$ bioaerosols with more microorganisms³³. It has also been shown that the majority of sporadic viral RNA from coughing in influenza patients is contained in particles in the respirable size range³⁴. Having good effect on fine PM and a smaller aerosol (diameter $\leq 5 \mu\text{m}$) are

important criteria that air purifiers need to achieve. Obviously, the purifier combination in this study was able to do this.

In this larger and separate space in hospital wards, one or more bacteria, and even super-resistant bacteria and viruses, can be detected in the exhaled gas of nearly half of hospitalized patients^{35, 36}, which gradually spreads throughout the room. When the purifier was run alone in this study, it showed poor effects on some locations, which was greatly related to the purifier ventilatory efficiency and room layout. For example, in a ward with a patient with SARS-CoV-2, the virus was widely distributed on the floor, a computer mouse, trash buckets, and the patient's bedside banister and was detected in the air about 4m away from the patient³⁷, even as the air flow reached the outside of the ward³⁸. Interestingly, PNOI produces ions capable of diffusing everywhere with the aid of the ventilation system and the airflow of HEPA. As the present study presented results that bacteria and viruses were more easily purified, the purification rates were not statistically different among the seven sampling sites. Another unexpected phenomenon was that the pathogenic aerosols derived from patients or those carrying pathogenic bacteria are highly prone to stay in humid environments, such as those in toilet air, pools, and buckets³⁹, where microbial decontamination is relatively poor. Because the toilet is small, installing an efficient cleaner for the toilet is clearly cost-effective. A ward toilet was not actually used as simulated in this study, so decontamination may have been overestimated. Purifiers need to be considered for installation near more contaminated areas, such as toilets, in real-world situations or for enhanced sanitization of these areas.

At present, one of the most common and predominant methods of disinfection of areas such as hospital corridors, wards, nurse stations, and doctors' offices is the use of disinfectants for the cleaning of surfaces on the ground and objects⁴⁰. This approach, while fully effective, requires significant human effort to be invested and is not durable. Studies have shown that heating, ventilation, and air-conditioning systems in hospital wards are the main indoor ventilation facilities and another important means of infectious disease control, but their incorrect use can instead lead to the spread of disease⁴¹. Under the influence of the new corona virus, the air cleaner has a better prospect for use in the medical arena. However, as the HEPA purifier in this study was capable of clearing airborne particulates and aerosols by requiring air to pass through its strainer, it is clear that its effects are not comprehensive. There are studies evaluating the effectiveness of a certain plasma cleaner for 20 days, and it was found that it did not affect bacteria and fungi in the air of the hospital ward⁴². Marc's study indicated that no statistically significant differences were found between the use of portable air disinfection systems and the use of natural HVAC systems in two health care self-learning rooms⁴³. Therefore, in complex air pollution locations such as hospitals, proper selection of air purification equipment is required. The combined application schemes demonstrated in this study do exhibit good synthetic ability, but this does not mean that they are the best combination. This study hopes to give more ideas and inspiration to related researchers and producers while providing a protocol for the use of a purifier and also to demonstrate an effective method for the comprehensive evaluation of purifiers.

In summary, under a simulated heavily polluted environment, the combination of two kinds of purifiers with different characteristics effectively improved indoor air particulate and microbial pollution and were also fast and effective. However, failure to evaluate a real scenario is a limitation of this study. Further validation of their actual effects in real-life scenarios is also required.

CONCLUSIONS

In this study, we comprehensively evaluated the effects of two air purifiers, alone and in combination, by simulating the indoor environments with severe PM, *S. albus*, and influenza virus pollution. The results

showed that HEPA and PNOI alone had limited effectiveness for purification. However, in combination, it can obviously improve the purification capacity, narrow the purification difference for pollutants in different positions and for different particle sizes and inactivate some airborne influenza viruses. Additionally, it has a better purification effect on airborne microorganisms than ordinary UV disinfection.

AUTHOR CONTRIBUTIONS

B.Z. was involved in methodology, investigation, data curation, formal analysis, and writing—original draft preparation, reviewing, and editing. T.L. was involved in conceptualization, project administration, methodology, data curation, and reviewing. S.Y. was involved in investigation, data curation, and formal analysis. Y.H. and Y.G. were involved in data curation, formal analysis, and reviewing. S.H. and C.Z. were involved in data curation and methodology. H.C. and R.Z. were involved in conceptualization, funding acquisition, resources, reviewing, and supervision. All authors have read and agreed to the published version of the manuscript.

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Not applicable.

INFORMED CONSENT STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable. No new data were created or analyzed in this study.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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中医神志理论中神气的概念探讨

杨常青 / Changqing Yang

精神医学博士，加州中医师

做为一名合格的中医师，必须了解中医的基本概念，而且不能有丝毫的含糊。因为这些中医基础理论的基本概念不仅影响对中医理解的深度和广度，而且影响临床治疗的思路的清晰度和准确度，以及治疗方案和具体方法的最佳化选择。本文试图主要以中医经典《内经》为依据，简单扼要地阐述一下中医的精气神，以及一个非常重要却被长期忽视的概念即“神气”，本人长期从事中医神志病临床及教学事业，所以，借此机会将这一历久弥新的概念和其意义进行一个基本的阐述。

一、关于精气神

（一）精

我们再了解一下理解“精”这个含义。《说文解字》中言“精，择也。从米青声。”也就是认为，选择上等的米是精的本意，这就是精微物质含义的来源。在《素问·金匱真言论》中有“夫精者，身之本也”的言辞，所以，广义之“精”，是指人体内的五脏六腑，五体百骸，五官九窍，以及经络血脉等一切具有物质性的或者是有形可依的物质性存在，这是身体存在的根本。所以，“精”也就是今天所共知的是泛指构成人体和维持生命活动的基本物质。

中医认为，精包括先天之精和后天之精。禀受于父母之精是先天之精，是《灵枢·本神》篇的“两精相搏为之神”的精，人身生于父母，而父母是天地之代理，奉天地之道而行生育繁衍之事，所以它是先天的，是定数。《灵枢·经脉》篇明言：“人始生，先成精。”也就是说人的生命是天地自然的精纯之物，人的生命活动一开始运作就是构建人体，就是胚胎的发育过程。所以，依据这个先天之精的概念，才能较好地理解后天的各种狭义之精的概念。而狭义的精有几个层面，如五脏所藏之精。《素问·本神》认为：“是故五脏主藏精者也。”还有在五脏之中就是“肾藏精”这一狭义的概念。肾主骨生髓为人身阴阳之根本。

（二）气

关于“气”的认识《说文解字》曰：“云气也。象形。凡气之属皆从气。”我的《内经》王若詮老师在上世纪八十年代就曾说过，“气是宇宙间最基本和最微小的物质。”用今天的话来说就是所有物质的共同的基本粒子。中国古代的哲学家早已论述了哲理的气的概念，如《周易·系辞》中就有：“天地氤氲，万物化醇；男女构精，万物化生”之说。再如《庄子外篇·知北游》说：“人之生，气之聚也。”

聚则为生，散则为死”。所以，气是构成天地万物最基本的物质，而且，从这个气本源论，或是一元论的观点来看，可以说只有气的运动才是宇宙万物的发生，发展和变化的根源。

中医认识气的概念的重点在于气机气化，认为气机气化活动是气的基本特征。正如《素问·六微旨大论》指出的那样：“出入废则神机化灭，升降息则气立孤危。故非出入，则无以生长壮老已；非升降，则无以生长化收藏。是以升降出入，无器不有。故器者生化之宇，器散则分之，生化息矣。”所以，气机就是气的升降出入运动方式，而且认为有升必有降，有降则必有升。在同一篇又有“升已而降，降者谓天；降已而升，升者谓地。天气下降，气流于地；地气上升，气腾于天。故高下相召，升降相因，而变作矣。”实际上，气机的升降运动就是事物的循环往复之理；而气机的出入运动就是对事物的变化之理。也就是说，无论宇宙中的事物周期有多长，总要进行循环往复的周期性运动，只不过有的事物周期超长而不容易被人类观察得到而已。同时也可以认识到无论事物的存在有多么合理和多么坚强，总有由于气的出入而产生变化之时，一切事物的变化只是个时间的长短问题，这就是气的气机气化之理。

（三）神

“神”则为形声字，示旁申音，《说文》言：“示，天垂象，见吉凶，所以示人也。从二，三垂，日月星也。观乎天文，以察时变。示，神事也。凡示之属皆从示。”所谓“天垂象”就是上天的启示，这是古人的信仰。《说文》对神的解释是“神，天神引出万物者也。”在《广韵》中认为：“神，灵也。”也就是神与灵相通用，可以指人的精神活动。由上可知，所谓本神就是“本于神”，或“以神为本”。同时，也可以体会出，人之神是与自然相通，是天人相应的。天垂象于人，给予人以启示，人的心灵要依据天地自然的启示，而施行所谓应天地之道的生命活动，才能维护自然的平衡和人体的身心健康，这是中医学自然生命观的原点。

《内经》作为一本至高无上的医学经典著作，是以医学理论与实践为主导思想的，故可以称之为“医学圣经”。因此，《内经》本神理论学说的核心观点就是临床诊治疾病之时要以神为本。实际上，这里已经揭示了神源自于自然，是生命之本，人禀赋于天地自然而生人的生命本质，所以，中医的“神”绝不是迷信的说法，而是有两个重要的含义，一个就是神在于人体就是生命，神根于气，故而神气就是生命的能量和生命力；而神的另外一个狭义的概念就是人的意识，即人的心理功能活动，也是属于生命能量的范畴，是在神气的流转过程中所实现的生命功能活动。

（四）关于“精气神”的相互关系

既然“气”是构成天地万物最基本的物质，无论“精”还是“神”都是以气为根。《素问·宝命全形论》有言：“夫人生于地，悬命于天，天地合气，命之曰人。”所以，在人这个生命体就有两种气的形态，一个是精气，还有一个就是神气。正如前所述，精气就是有形质的气，而相对于精气就是神气，神气的广义是人的生命之气，狭义是指人的意识思维心理之气。中医将精与气结合起来就能够理解事物之间的气机气化之理，同理，将神与气结合就能理解神气的升降出入变化，以及其生理的正常属性和病理的临床特点。

由于气为万物之根和生命之本，所以，神气和精气同样按照气的气机气化规律进行流转。二者在生理上相互依存，病理上相互影响。临床上，有心理问题的人，或是患有神志病的人 经常出现躯体化的临床表现而且症状繁多，这都是神气的失调进而导致了精气的异常反应；反之亦然，属于精气失调的诸如慢性炎症，内分泌失调，内脏的各种不适 也可以导致神气出现反应，可以出现心烦意乱，烦躁不安，抑郁焦虑等。所以在临证之时，一定要辨别标本先后，病因与结果，否则本末倒置，不知所宗。以神志失调为病因的临床问题，一定要以治神为本，要进行神志辨证为主，再结合脏腑辨证而达到形神和一。

中医认为精是神的居所。中医认为神需借助人体的组织器官而实行其功用，其中，心是人的神明功用之首而总统魂魄意志，所以《素问·灵兰秘典论》认为：“心者，君主之官也，神明出焉”，并且在《素问·六节藏象论》中指出：“心者，生之本，神之变也”，所以在《素问·宣明五气》篇中归纳为：“心藏神，肺藏魄，肝藏魂，脾藏意，肾藏志。是谓五藏所藏”。要注意的是五脏是“藏神”，即神以五脏为居所，而并非五脏产生五神，换言之，神是以五脏为首的人体器官组织为居所而进行各种功能活动的，即进行生命和神明的功能活动，实际上，中医的五脏神的概念就是现代心理学对潜意识的理解，使人的深层意识活动。这就是为什么通过打坐，气功，凝神以及心理暗示等都可以调神，机进行心理治疗。

二、神气的概念

谈神气就必须谈“本神，”本神的概念源自于《内经·本神》篇，“本”是一个指示字，指树根，所以，本神就是神是本，临床上中医诊断治疗疾病特别是治疗神志病，也就是现代的精神疾病就一定要以神为本。如前所述，神气的概念是关于神的，是从神的概念中衍生出来的重要概念。所谓“神气”是将“神”与“气”结合在一起所形成的一个特殊的概念。在宇宙中，“气”是最基本的存在，这里姑且将气称之为能量进行讨论。迄今为止气至少有两个方面的能量特征，一个是物质性的，物理性的能量，是人类科技容易理解和测量的，可以称之为物质之气，如精气，谷气等；另外一种精神性的，灵魂性的能量，这种能量不遵循现代物理学，甚至生物化学的规律，中医称之为“神气”。

（一）神气来自于天地自然

中医学认为，人的神本于气，实际上，精气神是三位一体的，然而精与神都是根于气的，故此，人的神气也是本于自然的。神气并非神秘不可测，神气是天地自然的一种能量或是一种存在而已。《天元纪大论》认为：“夫五运阴阳者，天地之道也，万物之纲纪，变化之父母，生杀之本始，神明之府也，可不通乎！”所以，五运阴阳的天地之道是神明活动的产生之处。《本神》篇中言：“天之在我者德也。”清楚地指出了人之德性是来自于上天自然，人体自身是不会产生德性的。要注意的是《内经》理论强调的“德”是符合天之清阳之气，有天真属性的清明之德。这个德是人的灵性，可以称之为神灵。所以在《四气调神大论》中指出：“天气，清静光明者也，藏德不止，故不下也。”所以说，天

之气的清静而且光明，说明了天地自然环境能够哺育生命的生机。天之德是无止境的，是生机永续的，是任何生命得以延续的根本。人的生命之所以能够延续，代代相传，而人的神灵活动，神气的活动是不会终止的，这就是天之德在人身上的功用。

（二）神气以人体为居所

如前所述，神气源于自然而寓于人体，不仅赋予人体以生命，而且使人能够有神志心理的神明活动。人体就是神的居所，随着阴阳两精的结合而有神来居。《本神》篇认为：“两精相搏为之神”，《太素》在注释中认为“即前两精相搏共成一形，一形之中，灵者谓之神也，即乃身之微也。问曰：谓之神者，未知于此精中始生？未知先有今来？答曰：案此《内经》但有神伤、神去与此神生之言，是知来者，非曰始生也。及案释教精合之时，有神气来讫，则知先有，理不虚也。”黄元御在其《灵枢悬解》中也认为：“人秉天地之中气而生，天之在我者，五行之德也，地之在我者，五行之气也。五神者，德流于上，气薄于下而生者也。精者，生化之始基也，故生之方来，谓之精。人身形象之根源，神气之室宅也。”可知不仅神藏于人体之内，神气也是以人体为其居所流转不息。这些理论完全符合《天年》篇的观点而认为：“黄帝曰：何者为神？岐伯曰：血气已和，荣卫已通，五藏已成，神气舍心，魂魄毕具，乃成为人。”可见是神气舍心，以心为其宅室，在人生命最初生成之时，元神舍心而生命过程开始。

（三）调节神气是治疗之要

传统中医认为无论针灸，中药，还是按摩气功等治疗活动，都是对人体的气机进行必要的调节，所以，都会影响人的精气与神气的活动。在神志病的治疗上是必须要调节神气的活动才能达到神志养生和神志病治疗的目的，所以，调节神气是治疗神志病的关键。实际上，调神不仅对于神志问题，即使是躯体性问题也同样重要，在《汤液醪醴论》中就有“神不使”的概念，指出了人的神志失调，即人的神气活动失调，可以影响针灸和药物治疗的效果，认为是：“针石，道也。精神不进，志意不治，故病不可愈。”原因就是“嗜欲无穷，而忧患不止，精气弛坏，营泣卫除，故神去而病不愈也”。这种原因所导致的状态就称作是：“今良工皆称曰病成，名曰逆，则针石不能治，良药不能及也。”可见神志活动对治疗影响之大。正如文中论述疾病与医生之间的关系是：“病为本，工为标，标本不得，邪气不服，此之谓也。”这种形神相互影响的观点，对于今天的临床实践活动仍然具有积极的指导作用。这种医学模式与今日所谓的社会心理生物医学模式比较，更具有中医特色的整体观念和辨证思维。

三、神气理论的现实意义

（一）指导中医神志病的临床治疗

神气的概念直接指导着临床实践，这是神气概念最为重要的意义。将神与气相结合就将难以捕捉和量化的神志问题，以气机气化的概念形式表达出来，使中医临床诊断和治疗变得极为方便。因为将气机气化的概念引入人的神志概念之中，并用以描述神的功能活动特点，因此，气的升降出入，离合

聚散，强弱迟速都可以应用于神志的诊断上，从而使神志病的诊断和治疗更加具体化和实用化。神气在总体上的倾向性就可以有阴阳癫狂之不同，神气自身又有气机运行的特点，还有神气功能活动和五脏五神的特点和特征，神气也出入升降于全身而表现出丰富的躯体症状，使中医神志的诊断有了清晰的层次，治疗上就可以执简就繁，纵观全局整体而又能兼顾局部微观，从而提高临床的治疗效果。

（二）弥补中医神志病证候的缺失

自《内经》以下，大多医家治疗神志病都是以脏腑辨证为诊断方法，没有神志辨证，由于脏腑证候并非是神志证候，造成临床神志诊断信息的严重缺失，这种用脏腑证候取代或涵盖神志辨证的方法并非是《内经》的本意。《内经》有以脏为本的“本脏”；有以腑为本的“本腑”；还有以临床病状为本的“本病”观点；同时还有以神为本的“本神”观点，因此，恢复经典中治病必本于神的理论是不可缺失的，也是现今中医神志病临床非常迫切需要的。如果不了解患者神志的阴阳癫狂属性，不知晓神气的运转状态，也不全面收集五脏之神失调症状，仅仅以一般的脏腑证候的诊断治疗方法诊治神志病，是极其不完整和非常容易出现偏差和错误性治疗的。如临床上神气过度升发则宜用降法，而生发不足则宜用提神之法，而二者皆可以发生在同一个脏腑证候上。其他如神气外散则宜用敛神之法，而神气呆滞当用动神之法，诸如此类都需要先了解神气的证候特点。

（三）恢复中医神志理论的经典概念

“神”并非是个神秘的概念，更不是一个充满迷信色彩的词汇，而是极具科学性的概念。但是，当神的概念与皇权结合，关于神的概念就不是随意可言的，当然还有认知手段，思维方式都还处于禁锢和封建的习惯，不仅平民百姓，就连学者专家也不免谈神色变而心生忌惮。封建专制不仅垄断了技术，也垄断了技术的应用，严重阻碍了社会的科学进步，对一些难以解释的人们的神志现象，特别是一些严重的精神疾病望而却步，心生畏惧，就连医家学者也不免要敬而远之。一些封建迷信利用这些条件却是大行其道，欺骗民众，就会更加使人心生厌恶而避之。反复揣摩《内经》理论则可以得知，中医学的历史上确实经历过辉煌的时期，其自由学术之风气见着于歧黄之言语；敬师好学之习俗显现于皇帝之举止。皇帝躬躬行礼拜谢岐伯，盛赞其学术渊博而又多次请教礼贤下士就是为了“愿闻其道”。

几千年的临床实践告诉我们，中医关于神以及神气的概念与论述是非常科学和具有重要价值的。人的生命源于宇宙自然，处于天地之间，由此可以理解到人不是自己产生神志活动，而是自然的神气能量以人的身体为居所来进行表达，而且这是天地自然的造化之机，即宇宙进化和运转的一个组成部分而已。恢复包括神气在内的中医神志理论的概念不仅具有临床实际价值，而且对中医的未来和现代的生命科学都会具有重大的影响和参考价值。

（四）丰富中医神志学说的理论内容

可以说在相当长的一段时间内，几乎就是在《内经》的出现之时直至今日，中医关于神志学说及其理论的发展几乎是一个空白。在这一段历史中仍然不乏有一些闪耀着本神实践与观点的探讨。其中

唐代医家孙思邈的学术观点大大地丰富了医学伦理和中医精神养生方面的内容，其十三鬼穴之说仍然留下许多谜团和争议。杨上善的注释较为贴近原貌，然而经过王冰的整理可能已是面目全非。尽管如此，仍然有象明代张景岳这样的一代医家和学者，能够尽量忠实于《内经》的原意加以阐述，认为应该是“以灵枢启素问之微，素问发灵枢之秘”的以经解经，慎密细致，回归原味的读经方法和严谨的治学态度，对中医学和神志学说的贡献颇为巨大。然而，不无遗憾的是，无人能够将《内经》的神志理论系统地整理和发掘出来。近些年来，一些中医心理学和关于神志学说的书籍相继问世，进步有目共睹，但是内容过于浅显。理论上的论述经常受到哲学和认识观点的偏见，不能详细论述以《内经》为代表的中医神志学说理论的系统性和完整性。

（五）形成中西医精神医学的触点

中西医之间虽然有着巨大的差异，然而至少在临床上相互之间又有很强的互补性。中医的优势就在于将生命回归自然，就是用天人合一，天人相应的观点来理解生命活动和其各种现象，因此，中医诊治疾病一般是从宏观着眼，微观入手，整体与局部结合，同时，还要四诊合参，从整体的信息中体会和把握局部的微观变化。从以往的经验来看，西医学的精神疾病诊断经历了不同的发展过程，因此，在其诊断标准中的每一个病名和症状都有着西医临床精神科医生的思考。虽然中医诊治疾病也是受到医生个人的经验与知识的影响，然而，中医却是在一个更加广阔的背景下来研究生命，而非仅仅是疾病自身，这种整体观是中医学的优势。但遗憾的是，只是应用目前的中医诊断方式，忽视或完全不采用中医特有的神志辨证诊断方法，中医的整体性优势就会失去。

（六）打开人类意识奥秘大门的钥匙

认识神气是打开人类意识大门的钥匙，神气是认识和理解人类生命与心理各种功能的重要概念之一。从目前的研究和临床实际情况来看，无论现代医学，还是现代科技，都不能对人的“意识”有一个完整的，科学的解释。意识在近代，因为有了潜意识，无意识的学说理论，使现代人类对人的心理有了较大的提升，然而却是极为有限。意识即是所有心理功能活动的总和，又是心理整体的存在，从某种意义上来说，神气就是对意识到总体上的认知。对意识的研究和探索，充满了挑战与诱惑，令科学家趋之若鹜，因为突破对意识认知的瓶颈，就会真正把握人的意识动态，才能进入理解和把握心理的细化功能，心理芯片植入才能成为可能，否则只能停留在科幻电影里。

现代医学对人类意识的研究严重依赖对脑神经科学的研究，所以，也就不可避免地带来一些认知上的局限。首先，人的精神活动不可能是一种或几种化学递质，或一个和几个传导束的反应，人的神志活动始终是非常复杂而又非常综合的神志功能活动，具有其自身的特殊性。其次是人的精神现象绝不等同于生物化学现象，实际上应该是生命现象，生命现象还有大量未知的科学道理没有被揭示和理解。三是人的精神心理过程不能等同于神经化学的反应过程，目前的研究和进展已经表明了精神活动还有非化学的，难以解释的现象。四是人的精神活动绝不会只是人的大脑的功能活动，而应该是人身整体的生命活动的综合反应，可以表现于大脑而为“意识”所认知，是脑为心之用。大脑是前台的演员，

而心才是人生的导演。五是人的精神活动绝不只是人体内部的功能活动，而是与外部环境相互关联的，动态协调的结果，是符合中医阴阳运气规律的现象与结果。

今天的生命科学几乎成了分子生物学的代名词，而脑科学几乎也成了精神心理科学的代名词，然而这些研究手段只是生命科学的研究方法之一，随着科技的进步，还会有诸如量子科学的研究手段，就会使生命科学再次获得更大的提高。中医对人的神志功能的认识是从阴阳为始，首先就是兴奋和抑制，正性和负性，增强和减弱等现象得以认知，其次就是神气是生命的功能活动，反应于各个组织细胞以及微观分子的功能代谢活动，神气的概念揭示了生命能量，信息的整体关系和整合作用，生命能量与信息的人体内部交流与外部的交通关系，所以说中医神志学说是理解生命科学的重要思维方法和理论体系。通过中医神志理论的学习，可以认为人的生命活动是整体的，综合的，动态的，体用结合的，物质与功能并在的，人体内外协调的，符合自然规律和生命周期的存在与反应。

地震断裂带多层结构的 低速波导效应数值研究

Numerical Study on Low-velocity Waveguide Effect of Multi-layer Structure in Earthquake Fault Zone

郇永刚 / Yonggang Li

南加州大学、加州地震中心

University of Southern California, California State-Wide Earthquake Center

摘要

地震破裂带在层状地壳中形成与深度相关的多层低速波导 low-velocity waveguide (LVWG)。断层低速波导 LVWG 将聚合地震波能量,引导震波以正态模 (normal-mode) 形式在 LVWG 内部传播。我们对地震破裂带多层结构的波导效应进行三维有限差分数值模拟研究。结果表明,当地面接收台站和地下震源均位于断层低速波导 LVWG 内时,合成的断层陷波, fault-zone trapped-wave (FZTW), 或称断层导波在横波 S 后显示大振幅长持续时间具有波散特征的波列,并且出现多个振幅峰值。在 S 波后 FZTW 波列持续时间与 P 波至 S 波时差之比值 (PSSP ratio) 通常大于 1.2。FZTW 波列的前部产生于多层低速波导 LVWG 中速度较慢的浅层,显示较大峰值和较低频率; FZTW 波列的后部产生于 LVWG 中速度较快的深层,显示较小振幅峰值和较高频率。当震源位于地震破裂带外时,一旦震波进入多层低速波导 LVWG 的浅层层底也能够在其内产生大振幅的 FZTW。然而,它们显示持续时间短且具较少振幅峰值, PSSP 比值也远小于由位于低速波导 LVWG 内相同深度震源产生的 FZTW 波列的 PSSP 比值。由于大多数地震发生在宽度几十到几百米的狭窄断层破裂带之外,它们的震波仅能在进入断层多层低速波导 LVWG 的浅层内产生振幅大但持续时间短的断层导波 FZTW, 为此可能在分析和模拟野外记录的大量 FZTW 数据时导致低估断层破裂带的实际延伸深度。因此,在分析和模拟原始时,我们须仔细识别由少数发生在断层深部的地震产生的持续长且包含多个振幅峰值和具有较大 PSSP 比值的断层导波 FZTW 波列,以此确定地震破裂带的实际深度。

引言

1986 年我们在北加州奥罗维尔 (Oroville) 断层, 其上曾于 1975 年发生 M5.7 级地震, 的钻孔开展三维垂直地震剖面 vertical seismic profile (VSP) 野外实验中, 首次发现勒夫波类型 (Love-wave type) 的断层导波。当震源和接收台站都位于断层带内时, 记录的地震图显示在 S 波到达后出现大振幅长持续时间的具有频散特征波列。随后, 我们在加州帕克菲尔德 (Parkfield) 附近圣安德烈亚斯断层 San Andreas Fault (SAF) 内安装的地震台站 MM 记录的由发生在 SAF 内地震激发的震波数据中识别出类似波列。这些出现在 S 波后具有频散特征的大振幅和长持续时间波列首次被命名为断层陷波, fault-zone trapped wave (FZTW), 或称断层导波 fault-zone guided wave^{14, 15, 18, 21, 22}。

地壳内存在的断层通常被标志为几百米到数公里宽的低速带。它们被认为是在强地震期间岩体破碎以及高孔隙流体压力造成的^{37, 40, 42}。由于震波在断层内部破碎岩体中传播速度降低, 形成天然的低速波导 Low-Velocity Waveguide (LVWG)。当震波进入断层 LVWG, 在低速断层与高速围岩边界上的多次反射波相干作用产生大振幅长波列的断层导波 FZTW, 其振幅、频率和波形强烈依赖于断层的几何形状和物理性质^{5, 11, 15, 18, 19}。正确分析和模拟野外记录的断层导波 FZTW, 将有助于我们进一步深入了解断层带内部结构。

早期我们采用最简单的物理理论, 传播矩阵 (propagator matrix) 数据处理方法, 快速相移 (rapid phase-shift) 技术和 Love 波的格林函数³, 以及最简单的波导模型 (均匀非衰减弹性介质无限空间、平行断层面) 合成模拟野外记录的 FZTW。建立的模型参数包括断层破裂带宽度和带内震波传播速度, 以及震源和接收台站相对断层的位置。我们使用这个最简单的建模计算合成 SH/Love 类型断层导波波形, 在一阶近似意义上与圣安德烈亚斯断层 MM 台站记录的 FZTW 波形基本吻合, 获得断层低速波导的初步特征和物性¹⁸。1992 年南加州莫哈维沙漠兰德斯 (Landers) 发生 M7.4 级地震, 又于 1999 年在赫克托矿区 (Hector Mine) 发生 7.1 级地震。震后我们在地震断层破裂带布置密集测线记录断层导波并使用三维有限差分模拟记录的 FZTW 波形, 高分辨率获取发震深度的断层破裂带内部结构和物理性质。随后我们进一步在 Parkfield 圣安德烈亚斯断层以及 Landers 和 Hector Mine 断层破裂带开展重复地震实验, 揭示断层带同震破裂和主震后随时间的愈合^{20, 23-36, 44}。

震源深度处断层破裂带的三维几何形状和物性将影响同震破裂的发生和传播, 因而了介断层带的精细结构具有重要意义, 并可能为一些难以捉摸的震源参数例如: 断层“粗糙面” (asperity) 和“壁垒” (barrier), 以及从断层带向外辐射出去的震波的上限频率“fmax”提供依据。这将有助预测地震引起的地面振动强度^{1, 2, 9, 12, 38, 39, 41, 46}。Brune (1970)⁶ 根据观测到的强震地面振动记录的普遍情况, 在加速度谱中引入 ~10 Hz 的截止频率。Ida (1973)¹⁰ 将这个截止频率解释为震源效应, 并在他的滑移弱化 (slip-weakening) 模型中估算出临界滑移量 Dc 为 10cm 量级。Papageorgiou 和 Aki (1983)³⁹ 将这个截止频率归因于内聚崩塌区 (cohesive-zone) 的几何尺度大小, 内聚区在断层破裂滑移过程中起着空间平滑算子的作用。Kinoshita (1992)¹³ 证明震源控制的 fmax 可在 10 至 40Hz 之间变化, 具体取决于地震震源区几何尺度。根据 Papageorgiou 和 Aki (1983)³⁹ 的震源模型, 这个“fmax”范围可能对应于 50m 至 200m 宽度范围。最近, Ferry 等人 (2024)⁷ 通过数值研究同震断层外岩石碎裂与深度的依赖性及其对破裂动力

学的影响。他们观察到断层过程中形成的层外岩石碎裂区会显著降低破裂速度,即使破裂损伤带很狭窄也会延迟甚至阻止向超剪切 (supershear) 震波速度的转变。因而强调了将主断层面与其周围介质之间复杂的相互作用纳入整个孕震区至关重要。

地震断裂带多层结构建模和断层导波数值模拟方法

Li 和 Vidale (1996)¹⁹ 曾使用二维有限差分模拟断层导波 FZTW 研究各种可能的复杂断层结构和地质环境对观测和记录 FZTW 造成的影响,并展示随着震源和接收台站离开断层的距离增加, FZTW 波列振幅和长度将被弱化 以及断层带内部破碎岩石与周围硬岩速度对比度变化给予 FZTW 波形和振幅的影响。在先前的断层导波 FZTW 模拟中,假设断层低速波导 LVWG 内部的横波速度和衰减 Q 值是均匀的。然而,层状地壳中实际存在的断层通常在不同深度由不同年龄和岩性的岩体组成,形成与深度相关的多层低速波导 LVWG。本文使用三维有限差分计算程序合成地震图,展示多层波导对生成的断层导波 FZTW 波形的影响。三维有限差分程序在时间上为二阶,在空间上为四阶,计算三维空间中传播的全波场,三维模型中弹性介质震波速度和 Q 值是可以任意变化^{8, 43, 45}。计算中采用 x-y-z 坐标系 $400 \times 400 \times 400$ 单元网格,网格间距为 25m,模拟一个宽度、长度和深度均为 10km 的立方体。为了阻尼边缘效应,在每个轴上添加 20 个网格。每个波长至少占用 8 个网格点,使网格波散效应 (dispersion effect) 最小化⁴。多层低速波导 LVWG 放置在体块中部,距离模型边缘足够远。三维模型包含四层,每层厚度为 2.5km,如图 10.1a 所示。从顶层到底层 (L1 至 L4),层内纵波 P 波 (横波 S 波) 速度分别为 3.0 km/s (1.5 km/s), 3.5 km/s (1.75 km/s), 4.0 km/s (2.0 km/s) 和 4.5 km/s (2.25 km/s)。200-m 宽的多层低速波导嵌入具有自由表面边界的高速分层体积中, LVWG 内 P 波和 S 波速度比每层周围介质的波速降低 50%。放置在地表上的横跨断层 LVWG 的接收阵列台站间距为 50m。这个三维结构模型中的低速波导 LVWG 能够有效产生 2Hz 至 10Hz 的断层导波 FZTW。当网格间距为 25m,断层内最低 S 波速为 0.75km/s,合成 S 型 FZTW 的最高频率为 6Hz。当断层内最低 P 波速为 1.5km/s,合成 P 型 FZTW 的最高频率为 12Hz。三维结构模型中 Q 值与深度有关。表 1 所示模型参数。在模型中放置一个双耦合震源 (double-couple source),震源辐射模式为走向角 0° ,倾角 90° ,前角 0° 。我们使用这些模型参数合成断层导波 FZTW,研究断层破裂带多层低速结构的波导效应 (waveguide effect)。

多层低速波导建模和三维有限差分合成断层导波 FZTW

震源位于四层低速波导 LVWG 内产生的合成断层导波 FZTW

首先,我们建立一个从地表延伸至 10km 深度断层的四层低速波导 LVWG 模型来测试其对震波的波导效应。图 1a 示意模型中包含一个 200m 宽、10km 深的四层低速波导 LVWG,自上而下依次由称为 L1、L2、L3 和 L4 四层组成。每层厚度为 2.5km。表 1 中列出四层 LVWG 模型中每层内外的 P 波、S 波速度和 Q 值。震源 (红星标记) 位于 LVWG 内,震深分别 5km 和 10km;由震源至横跨断层的地表接

表 1. 四层低速波导的模型参数 (Model Parameters for Multi-Layered Low Velocity Waveguide)

模型参数 (model parameters)	层 1 (L1)	层 2 (L2)	层 3 (L3)	层 4 (L4)
层底深度 (depth of the layer bottom, km)	2.5	5.0	7.5	10.0
波导宽度 (waveguide width), m)	200	200	200	200
波导横波速度 (waveguide S velocity, km/s)	0.75	0.875	1.0	1.125
波导横波速度 (waveguide P velocity, km/s)	1.5	1.75	2.0	2.25
波导 Q 值 (waveguide Q-value)	30	40	50	60
围岩横波速度 (wall-rock S velocity, km/s)	1.5	1.75	2.0	2.25
围岩纵波速度 (wall-rock S velocity, km/s)	3.0	3.5	4.0	4.5
围岩 Q 值 (waveguide Q-value)	90	120	150	180

收阵列中位于 LVWG 内台站 ST25 (蓝色三角形标记) 的震中距分别为 0、5km 和 10km。震波接收阵列的台站间距为 50m。红色射线表示震波在四层低速波导 LVWG 内传播路径, 黑色射线沿低速 LVWG 和高速周围介质之间的边界传播的折射波路径。图 1a 右侧示意图详细描述来自位于 ST25 台站正下方 5km 和 10km 深度震源的各类震波的射线路径。标有 Fd1 至 Fd4 的绿线分别表示在震源和地表台站 ST25 之间 LVWG 各层 (L1 至 L4) 内传播的直达波射线路径。标有 Fr1 至 Fr4 的黑线分别表示沿 LVWG 中层 L1 至 L4 和周围高速介质边界上传播的折射波射线路径, 它们然后以临界角进入 LVWG 中各层。标有 Fz1 至 Fz4 的红线分别表示在 LVWG 各层和周围介质边界上反射波射线, 它们在 LVWG 各层内相干产生断层导波 FZTW 波列。

图 1b 显示根据图 1a 中模型计算在横跨断层接收阵列记录的三维有限差分合成震波图经过 <5Hz 低通滤波的垂直分量和平行断层分量。图中垂直棕色粗线表示低速波导 LVWG 宽度 200m。垂直蓝线和红线分别对齐 P 波和 S 波到达时间。垂直绿线分别对齐在多层低速波导内传播的直达 S 波到达时间。位于低速波导 LVWG 内台站记录到大振幅长持续时间的断层导波 FZTW 波列; 使用移动时窗测量的 FZTW 振幅在红色框内超过两倍噪声水平。标有 S 波后 FZTW 持续时间实测值的红色水平线条表示 FZTW 波列长度。这些在 LVWG 内由反射波相干产生的 FZTW 显示出多个振幅峰值。例如, 来自位于低速波导内 L4 层低 10km 深度震源的折射波沿低速波导与周围高速介质界面传播进入 LVWG 各层 (L1 至 L4), 在这些层内依次产生断层导波 FZTW 的 4 个振幅峰值。随着震中距从 0 增加到 10 km, 震源深度从 5 km 增加到 10 km, 整个 FZTW 波列持续时间从 ~4s 增加到 ~8s。图中灰线对齐震中距为 0、5km 和 10km 记录的 FZTW 波列长度, 灰线斜率显示 S 波后 FZTW 波列持续时间随其在 LVWG 内行进距离增加而延长。

根据我们在以往活动断层上进行的实验中记录的断层导波 FZTW 分析工作中取得的经验, 定义 S 波后 FZTW 波列持续时间与 P 波和 S 波到达时间差之比 $(tc-ts)/(ts-tp)$, 称为 PSSP 比值, 式内的 tp 和 ts 分别表示 P 波和 S 波到达时间, tc-ts 表示 FZTWS 波列在 S 波后的持续时间, 在此期间内 FZTWS 的振幅大于背景噪声水平的两倍。当 PSSP 比值高于 ~1.2, 表明位于断层内的震源和台站激发和记录良好的大振幅长波列断层导波 FZTW。上例中 LVWG 内震源 10km 深, LVWG 内台站记录的 FZTW 波列的

PSSP 比值为 1.8–2.0, 表明当震源和接收器均位于 LVWG 内, 生成并记录良好的 FZTW 波列。

然后我们使用美国地质调查局 (USGS) 的地震波分析程序 (SAC), 计算三维有限差分合成震波的振幅谱。图 2a 显示分别位于低速波导 LVWG 内外的地表接收阵列中心台站 ST25 和距其边缘 100m 处的台站 ST29 记录的合成震波 (<5 Hz 低通滤波) 振幅谱。震源位于四层 LVWG 内, 震深为 5 km 和 10km, 震源与台站 ST25 之间震中距分别为 0、5km 和 10 km (参见图 1a)。对每个台站上的振幅谱都使用固定比例进行归一化处理。位于低速波导内的台站 ST25 记录到的 FZTW 波列具有较大谱振幅 (红色框中) 和 S 波后较长持续时间 (水平红色线条长度表示测量的持续时间)。在低速波导外的 ST29 台站记录的波列振幅谱和持续时间长度明显降低, 表明断层导波 FZTW 对接收器相对于低速波导 LVWG 的位置相当敏感。台站 ST25 记录的 FZTW 波列中出现对应于 LVWG 四层 (L1 至 L4) 的四个谱振幅峰值, 来自 LVZW 中波速较低浅层的合成 FZTW 波列前部显现较大振幅峰值和较低频率。当震深 10km, 震中距为 10km 时, 台站 ST25 记录的 FZTW 波列在 S 波后总体持续时间为 8s, 波列中出现四个谱振幅峰值。当震深 5km, 在 LVWG 浅层 L1 和 L2 内产生持续时间 6s 的 FZTW 波列中仅出现两个谱振幅峰值。在低速波导 LVWG 内传播距离较长的 FZTW 波列显示较长的持续时间。低速波导内台站 ST25 记录的 FZTW 波列的 PSSP 比值为 1.8–2.0。表明当震源和接收器都位于低速断层破裂带内时, LVWG 对震波具有很强的波导作用, 生成大振幅长波列多峰值断层导波 FZTW。

为了测试低通滤波对 FZTW 波形的影响, 图 2b 展示在台站 ST25 记录的分别经过 <6 Hz 和 <3 Hz 低通滤波的合成 FZTW 归一化谱振幅。当震源位于低速波导 LVWG 内 (如图 1a 所示), S 波后 FZTW 波列的持续时间随着在低速波导内行进距离的增加而增长。经 <6 Hz 低通滤波的 FZTW 波列显示持续时间总长为 3.5–8 s, 其中出现多个振幅峰值; 而经 <3 Hz 低通滤波的 FZTW 波列显示持续时间较短 (2–6 s), 而且具有较少振幅峰值。这可以解释为, 主要在 LVWG 浅层产生的较低频率的 FZTW 波列前部仍留在经过 <3 Hz 低通滤波的地震图中, 但来自 LVWG 深层的较高频率的 FZTW 后部则被 <3 Hz 低通滤波减幅了。经 <6 Hz 滤波的 FZTW 的 PSSP 比值为 1.8–2.0, 大于经 <3 Hz 滤波的 FZTW 的 PSSP 比值 1.3–1.5。通过这些模型试验, 我们建议在识别和分析断层导波 FZTW 时, 应谨慎地对记录的原始地震图采用合适的低通滤波器, 确定断层破裂带真实的深度延伸。

我们进一步根据图 1a 中模型计算接收器阵列台站 ST25、ST29、ST35 和 ST45 记录的合成震波波形包络, 四个台站分别距离 LVWG 中心线 0、200m、500m 和 1 km。图 3 展示经过 <6 Hz 低通滤波后合成震波的归一化波形包络。图中显示在低速波导 LVWG 内台站 ST25 记录的 FZTW 波列波形包络持续时间较长 (3.5s 至 8s), 具有较大的振幅和多个峰值, FZTW 波列的 PSSP 比值为 1.8 至 2.0。而在 LVWG 外台站 ST29、ST35 和 ST45 记录的震波波形包络振幅要小得多, 持续时间也更短 (2s 至 4s), 震波的 PSSP 比值小于 1.0。当合成震波经过 <2 Hz 低通滤波, 其波形包络显示很短的 S 后持续时间 (2s 至 4s), 并且位于 LVWG 内外台站的 PSSP 比均小于 1.3。模拟试验表明, 产生于 LVWG 中波速最慢的顶层的 FZTW 波列前部频率低于 2Hz, 而来自 LVWG 中波速较快的深层的 FZTW 波列后部则频率较高。因此在使用滤波器滤除原始地震记录中噪声时需要注意采用合适的低通截止频率。如果滤波器截止频率过低, 则会造成来自 LVWG 深层的较高频率的 FZTW 波列尾部在记录的原始震波图中消失, 从而导致低估实际断层低速破裂带的延伸深度。

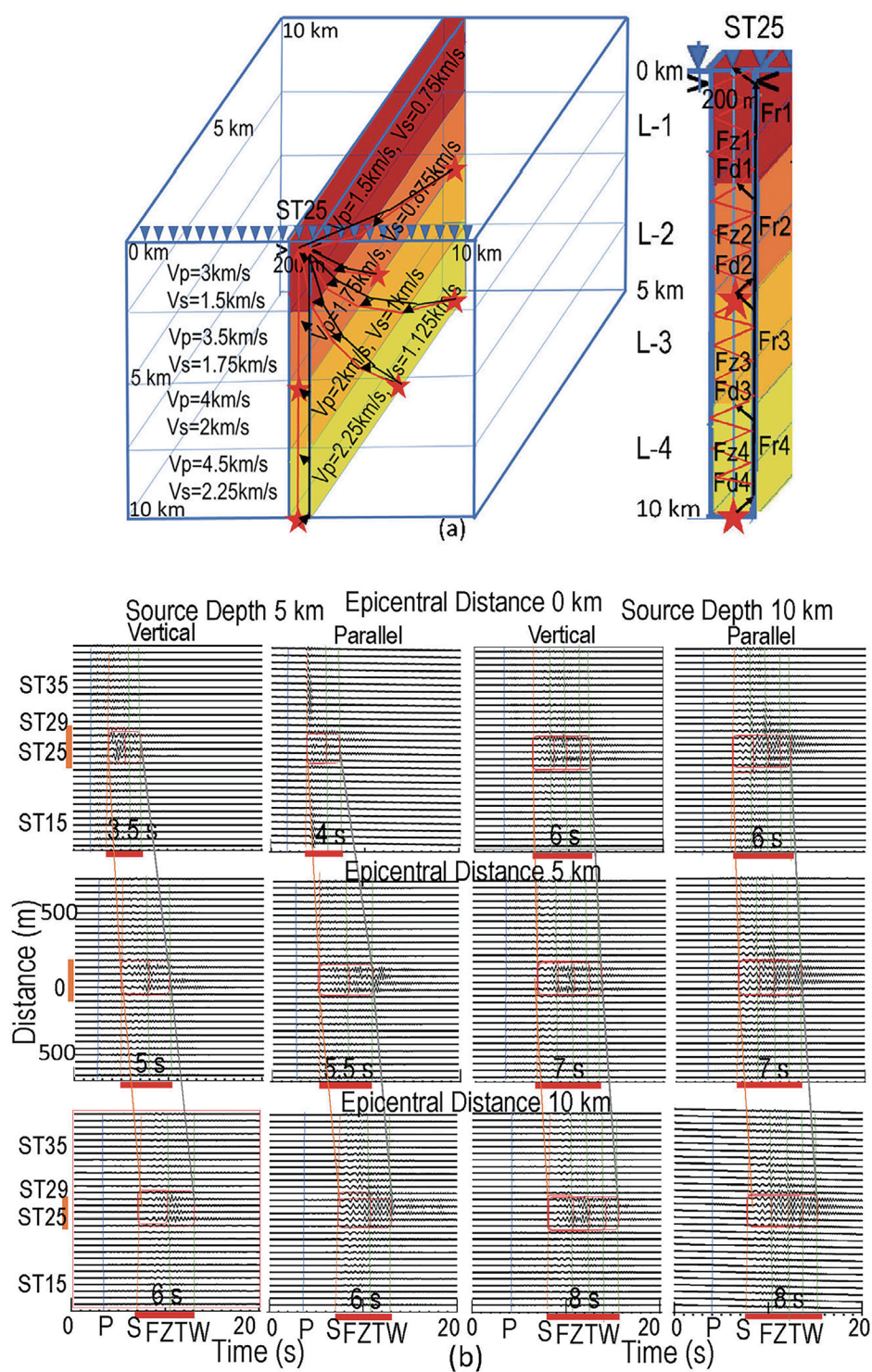


图 1. (a) 从地表延伸至 10km 深度的四层低速波导 (LVWG) 三维模型示意图, LVWG 内震源分别位于 5km 和 10km 深度, 震源至横跨断层的地表接收阵列中心台站 ST25 的震中距分别为 0、5km 和 10km。表 1 列出图中显示的模型参数。各类震波以及它们的射线已在文中描述。(b) 使用图 1a 中模型计算的三维有限差分合成震波图, 展示在横跨断层的地表接收阵列记录的经过 <5 Hz 低通滤波的合成震波垂直分量和平行断层分量。

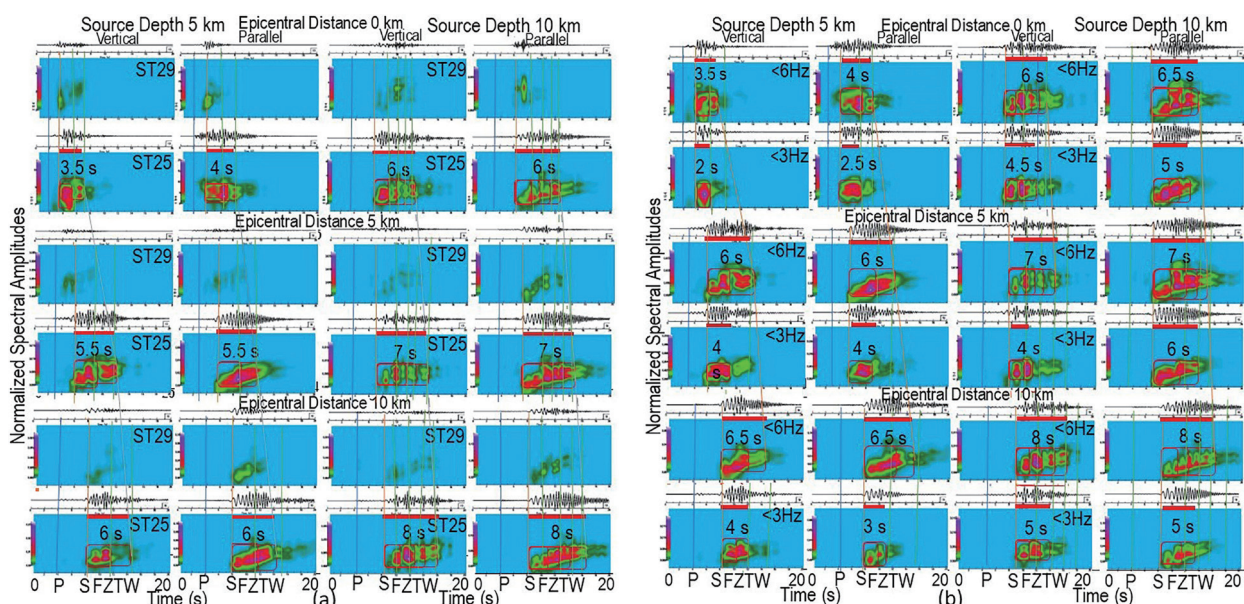


图 2. (a) 使用图 1a 中模型，对位于低速波导 LVWG 内台站 ST25 和 100m 外台站 ST29 记录的垂直和平行断层分量合成震波（经过 $<5\text{Hz}$ 低通滤波）计算的归一化谱振幅 (Normalized Spectral Amplitude): 图中垂直彩色条表示计算的振幅谱轮廓线振幅强度)。台站 ST25 记录的断层导波 FZTW 波列中出现多个谱振幅峰值，它们对应于 LVWG 的多层结构。(b) 使用图 1a 中模型，台站 ST25 记录的合成断层导波 FZTW 垂直和平行分量的归一化谱振幅。震波分别经过 $<3\text{Hz}$ 和 $<6\text{Hz}$ 低通滤波；经 $<6\text{Hz}$ 低通滤波的 FZTW 波列显示更长持续时间（红色线条标记），谱振幅中出现更多峰值。

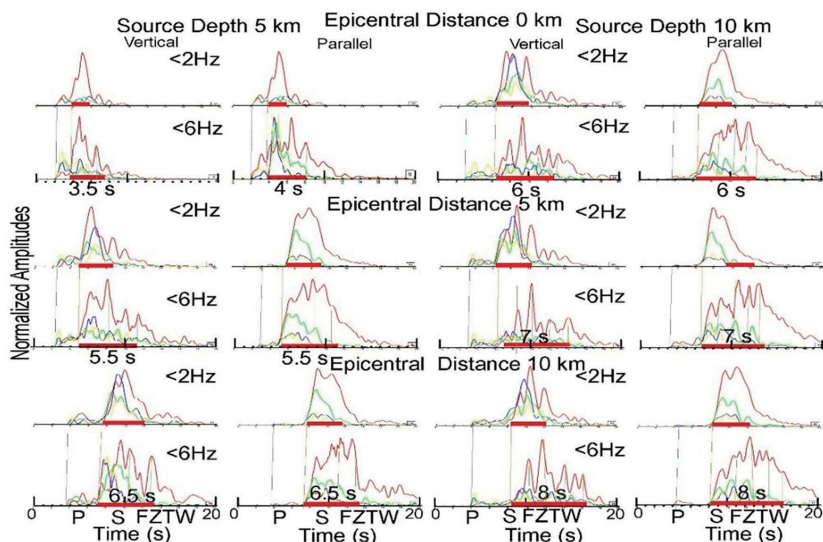


图 3. 图 1a 模型中距离低速波导 LVWG 中心 0、200m、500m 和 1km 的台站 ST25、ST29、ST35 和 ST45 记录的合成震波的归一化波形包络（分别由红线、绿线、蓝线和黄线表示），合成震波分别经过 $<2\text{Hz}$ 和 $<6\text{Hz}$ 低通滤波。台站 ST25 记录的经过 $<6\text{Hz}$ 滤波的地震图波形包络中可以看到 FZTW 的多个振幅峰值。

震源位于四层低速波导 LVWG 外 2km 产生的合成断层导波 FZTW

下一步,我们测试低速波导层状结构对于来自外部震波的陷波效应(trapping effect)。图 4a 展示模型示意图,震源位于 10 km 深的四层 LVWG 外 2 km,震深分别为 5 km 和 10 km,震源至接收阵列台站 ST25 震中距分别为 0、5km 和 10km。来自波导 LVWG 外震源的震波首先在高速周围介质中传播(蓝色射线表示路径),然后进入 LVWG 浅层底部(红色射线表示路径)在低速波导浅层内产生大振幅但持续时间较短的 FZTW 波列(图 4b)。其持续时间与位于 LVWG 浅层 L2 层底 5-km 深震源产生的 FZTW 波列同样长(参见图 1b)。这些振幅大持续时间较短的 FZTW 波列的 PSSP 比值约为 1.1,远小于位于 LVWG 内同样深度震源产生的长持续时间的 FZTW 波列的 PSSP 比值 1.8-2.0(参见图 1b)。因此,我们可以根据位于 LVWG 内部和外部震源产生的断层导波 FZTW 不同的 PSSP 比值区别两者。

随后我们使用图 4a 中的模型计算位于 LVWG 内外台站 ST25 和 ST29 记录的合成震波的谱振幅,震源位于 10km 深四层 LVWG 的 2km 之外,深度分别为 5km 和 10km,震中距分别为 0km、5km 和 10km。图 5a 显示位于 LVWG 内台站 ST25 记录的断层导波 FZTW 的较大谱振幅(红色框中),而位于 LVWG 外台站 ST29 记录的 FZTW 谱振幅很弱,这说明 FZTW 振幅强度与相对于断层低速波导 LVWG 的位置很敏感。然而,我们注意到在 LVWG 浅层 L1 和 L2 内产生的持续时间较短(2.5-5s)的断层导波 FZTW 谱振幅中仅出现一个或两个峰值。这些持续时间较短的 FZTW 的 PSSP 比值小于 1.3,远小于图 2b 中显示的位于四层低速波导 LVWG 内 10-km 深度震源产生的长波列 FZTW 的 PSSP 比值(1.8-2.0)。我们进一步计算位于距低速波导 LVWG 中心 0、200m、500m 和 1km 的台站 ST25、ST29、ST35 和 ST45 记录的合成震波(< 5Hz 低通滤波)的波形包络(图 5b)。此例中震源深度为 5 km 和 10 km,分别位于四层低速波导 LVWG 之内或 2km 以外,震中距分别为 0、5km 和 10 km;当震源位于四层低速波导内, LVWG 内台站 ST25 记录的断层导波 FZTW 波列显示大振幅长持续时间(3.5s 至 8s),包含多个振幅峰值。这些长波列 FZTW 的 PSSP 比值为 1.8~2.0。而位于低速波导外的其他台站记录的合成震波振幅很弱,持续时间很短,具有较少振幅峰值。当震源位于 LVWG 之外时,在台站 ST25 处记录的产生于四层低速波导 LVWG 浅层的断层导波 FZTW 虽具有较大振幅,但持续时间较短(2~4.5s),仅包含一个或二振幅峰值, FZTW 波列的 PSSP 比值仅为 1.0~1.3。

上面这些数值试验表明,即使源位于四层低速波导 LVWG 之外,只要震源深度低于低速波导浅层的底部,一旦来自低速波导外部震波由层底进入 LVWG 浅层就有能在低速波导浅层内部由多次反射波相干作用产生大振幅断层导波 FZTW。但这些 FZTW 在 S 波后持续时间较短,它们的 PSSP 比值远小于位于 LVWG 深层相同深度震源产生的 FZTW 长波列的 PSSP 比值。这将有助于我们识别来自 LVWG 内部或外部震源的具有不同波列长度断层导波 FZTW,从而在分析实际记录的 FZTW 数据时准确评估断层破裂带的深度延伸。

震源在两层低速波导(LVWG)下方 5km 产生断层导波 FZTW

下一步我们模拟从地表延伸至 5km 深度的两层低速波导 LVWG(图 6a)对地震波的波导效应。震源深度 10km,位于两层低速波导 LVWG 底部以下 5 km。震源与接收阵列记录台站 ST25 之间的震中距分别为 0km 和 10km。蓝色和红色线分别表示震波在低速波导 LVWG 外部和内部传播的射线路径;黑

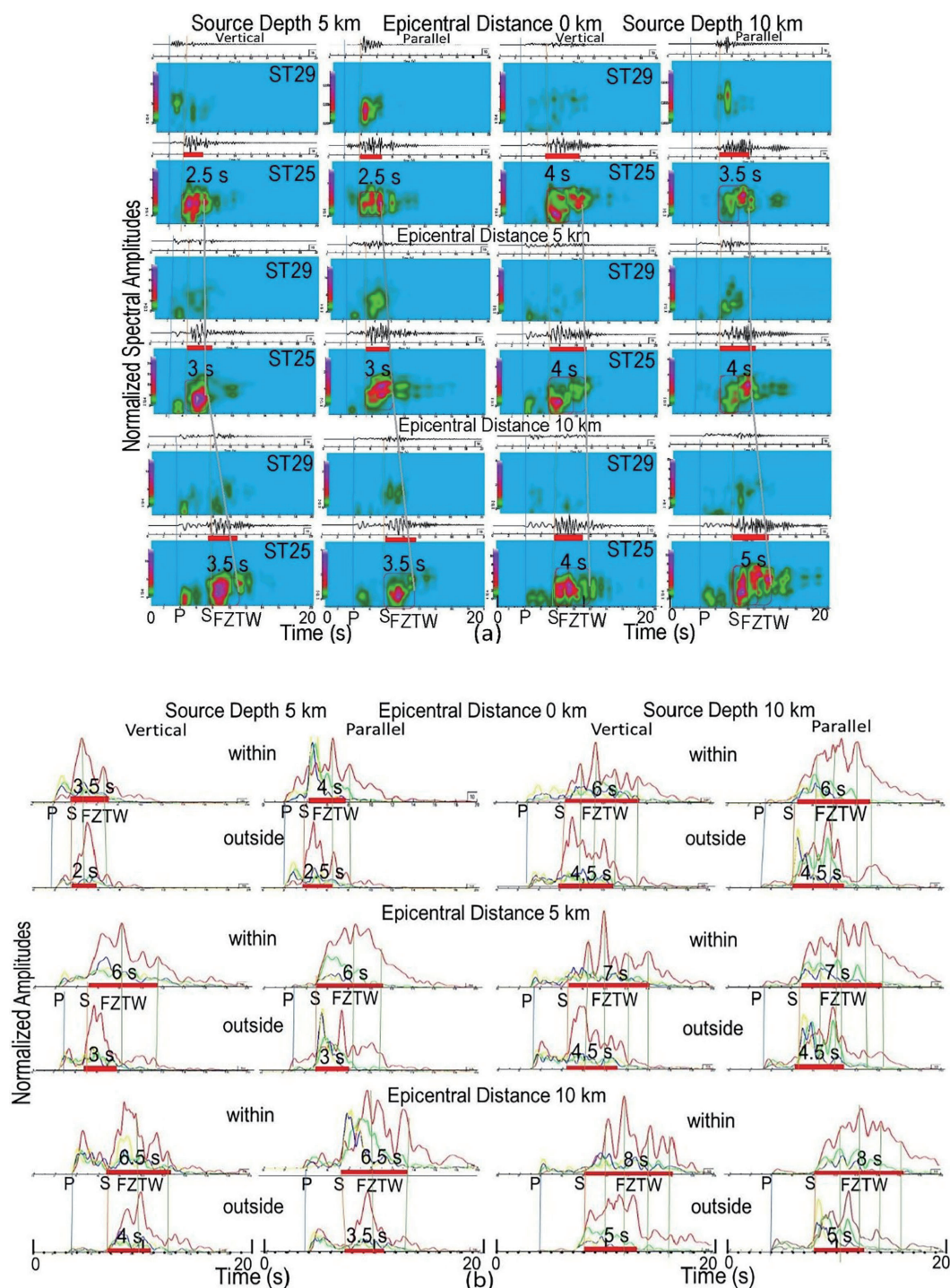


图 5. (a) 使用 4a 中模型和三维有限差分计算的合成震波 (经 <5 Hz 低通滤波) 的归一化谱振幅, 记录台站 ST25 和 ST29 在分别位于四层低速波导 LVWG 内外。震源位于 LVWG 以外 2 km。(b) 比较台站 ST25, ST29, ST35 和 ST45 记录的合成震波振幅包络 (分别由红线, 绿线, 蓝线和黄线标记)。震源分别位于 10-km 深的四层 LVWG 以内或以外 2 km, 震源深度为 5 km 和 10 km; 震源与台站 ST25 之间的震中距分别为 0 km、5 km 和 10 km。

色射线路径表示沿高速周围介质和低速波导之间的边界传播的折射波。图 6b 展示使用图 6a 中模型在横跨断层的接收台站阵列记录的三维有限差分合成震波图 ($< 5\text{Hz}$ 低通滤波)。蓝色和棕色线分别对齐到达的 P 波和 S 波首波。绿线对齐在两层低速波导 LVWG 的 L1 和 L2 两层内传播的直达 S 波。来自 10km 深震源的震波首先在高速周围物质中传播, 然后进入 5km 深度的 LVWG 底部。进入波导的震波在 LVWG 的 L1 和 L2 低速层内多次反射相干产生大振幅断层导波 FZTW。这些在 S 波后 FZTW 波列持续 4-5.5s, 其中出现两个振幅峰值。它们与位于四层 LVWG 内 5km 深度震源产生的 FZTW 波列很相似 (参见图 10.1b), 因为在这两个例子中断层导波 FZTW 在低速波导 LVWG 的 L1 和 L2 层内传播的距离相同。然而, 这些由位于 10km 深度震源在 5-km 深度的两层 LVWG 产生的 FZTW 波列持续时间远小于位于四层 LVWG 内同样深 10km 震源产生的 FZTW 持续时间波列 (7-8s)。尚且, 本例中由两层 LVWG 产生的 FZTW 波列的 PSSP 比值约为 1.3, 远小于由四层 LVWG 产生的 FZTW 波列的 PSSP 比值 (约为 2.0)。两个模型产生的合成断层导波 FZTW 的 PSSP 比值存在明显差异, 根据两者的 PSSP 比值明显差异, 将有助于我们在分析野外记录的断层导波 FZTW 数据时判断它们来自哪一种可能情况, 从而正确模拟和确定地震破裂带的实际深度。

图 6c 显示台站 ST25 和 ST29 记录的合成震波 (经过 $< 5\text{Hz}$ 低通滤波) 的归一化谱振幅; 震源深度 10 km, 位于两层低速波导 LVWG 底部以下 5km, 震中距为 0km 和 10km。位于 LVWG 内台站 ST25 记录的 FZTW 波列显示 4-5s 的持续时间, 但在距离 LVWG 200m 以外的 ST29 台站则未出现这样 FZTW 波列。

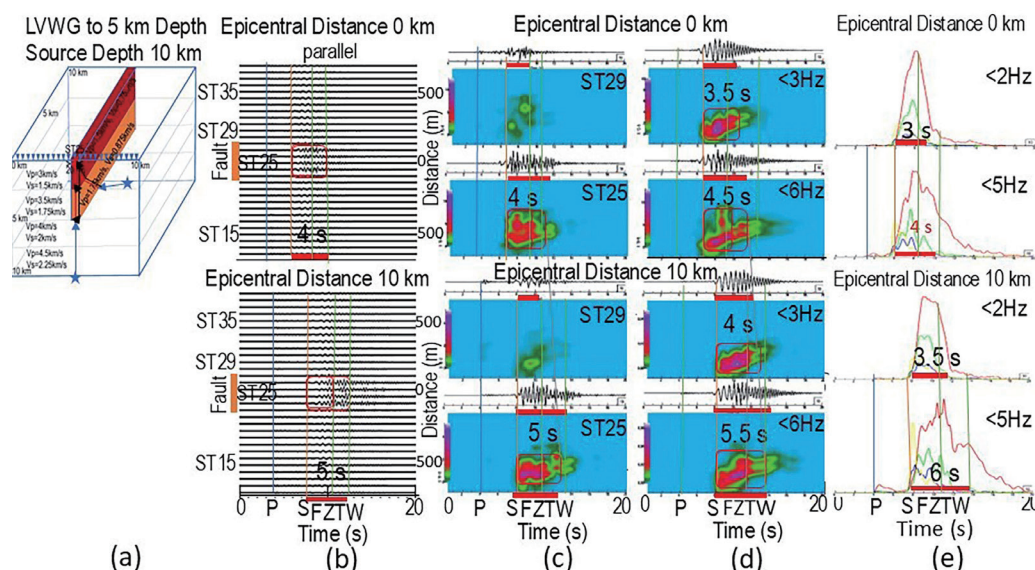


图 6. (a) 模型示意图, 模型中具有一个延伸至 5km 深度的两层低速波导 LVWG, 震源 (蓝色星号) 震深 10 km, 位于 LVWG 底部以下 5 km; 震源到地面台站 ST25 的震中距分别为 0km 和 10km。 (b) 使用图 6a 中的模型计算在横跨 LVWG 阵列上的三维有限差分合成震波图。 (c) 位于 LVWG 内外的台站 ST25 和 ST29 记录的合成震波的归一化谱振幅。 (d) 分别经过 $< 3\text{Hz}$ 和 $< 6\text{Hz}$ 低通滤波后的合成震波归一化谱振幅。 (e) 位于 LVWG 内外的四个台站记录的经过 $< 2\text{Hz}$ 和 $< 5\text{Hz}$ 低通滤波后合成震波的归一化波形包络。

图 6d 中展示台站 ST25 记录的合成地震图的归一化谱振幅, 分别经过 $<3\text{Hz}$ 和 $<6\text{Hz}$ 低通滤波, 显示出相似的 FZTW 波列持续时间, 这表明在 LVWG 的 L1 层和 L2 层内产生的 FZTW 的频率低于 3Hz 。图 6e 展示在台站 ST25、ST29、ST35 和 ST45 记录的合成震波的归一化波形包络, 合成震波分别经过 $<2\text{Hz}$ 和 $<5\text{Hz}$ 低通滤波。当 10km 深度震源位于两层低速波导 LVWG 下方, 台站 ST25 记录的 FZTW 波列的 PSSP 比值远小于位于四层 LVWG 内同样深度震源产生的 FZTW 波列的 PSSP 比值。因此, 我们在分析野外记录的断层导波 FZTW 数据时需采用适当的低通滤波器对原始震波滤波, 以避免削弱低速波导 LVWG 深层产生的 FZTW 波列尾部的高频振幅, 从而导致低估实际断层破裂带的延伸深度。

最后我们测试当震源深度 10km , 位于两层低速波导 LVWG 底部以下 5km , 并且与 LVWG 水平偏移 2km , 图 7a 模型中两层 LVWG 的波导效应。红色和蓝色射线路径分别表示在 LVWG 内外传播的震波。图 7b 显示三维有限差分合成的 FZTW 波列, 虽具有大振幅, 但持续时间 ($4\sim 5\text{s}$) 远小于由位于四层 LVWG 内 10-km 深震源产生的 FZTW 波列持续时间 ($6\sim 8\text{s}$)。但是, 它们与 5-km 深震源产生的断层导波 FZTW 波列持续时间 ($4\sim 6\text{s}$) 相似 (参见图 1b)。我们注意到, 它们与位于两层低速波导 LVWG 正下方 10-km 深震源产生的 FZTW 波列持续时间 ($4\sim 5\text{s}$) 相同 (参见图 6b), 因为在这两个模型中, FZTW 在两层低速波导 LVWG 的 L1 和 L2 层内传播距离相似。然而, 由于震源位于 LVWG 之外, FZTW 较短波列的

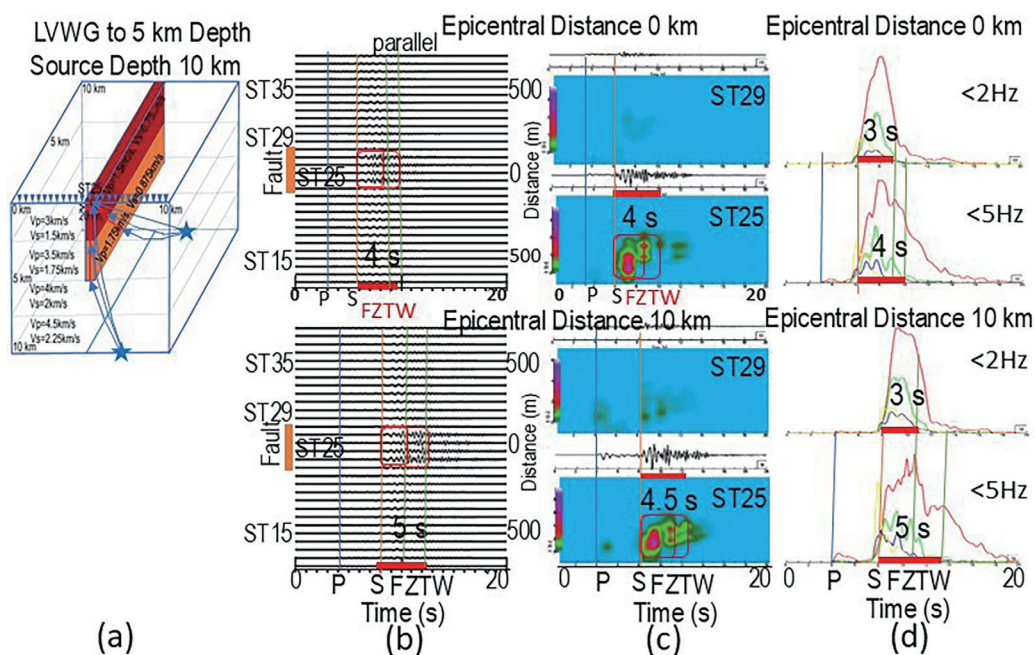


图 7. (a) 模型示意图, 模型具有一个 5-km 深度的两层低速波导 LVWG。震源 (蓝色星号) 位于 10 km 深度, 水平偏移 LVWG 2km , 震源到台站 ST25 的震中距分别为 0 km 和 10 km 。(b) 使用 (a) 中模型计算并在横跨 LVWG 阵列接收阵列记录的三维有限差分合成震波图 ($<5\text{Hz}$)。FZTW 波列在 S 波后持续时间为 $4\sim 5.5\text{ s}$ (以水平红色条标记), 其中出现两个振幅峰值 (红色框中)。(c) 台站 ST25 和 ST29 记录的合成震波 ($<5\text{Hz}$) 的归一化谱振幅。(d) 位于 LVWG 内外四个台站记录的合成震波归一化波形包络, 合成震波分别经过 $<2\text{Hz}$ 和 $<5\text{Hz}$ 低通滤波。

PSSP 比值约为 1.3, 远小于位于 LVWG 内同样深度震源产生的 FZTW 长波列的 PSSP 比值 (1.8–2.0)。图 7c 显示此模型中台站 ST25 和 ST29 记录的合成震波的归一化谱振幅, 震深 10km。位于两层低速波导 LVWG 内台站 ST25 记录的 FZTW 波列显示 4–4.5s 持续时间, 与位于台站 ST25 正下方 10-km 深震源产生的 FZTW 波列的持续时间相似。但在 LVWG 之外台站 ST29, FZTW 的振幅明显减弱。图 7d 显示此模型中台站 ST25、ST29、ST35 和 ST45 记录的合成震波的归一化波形包络, 震深 10km。位于 LVWG 内台站 ST25 记录的经过 <5 Hz 低通滤波的 FZTW 波列显示 4–5s 的持续时间。但经过 <2 Hz 低通滤波后, FZTW 波列持续时间仅为 3s, 这情况与图 6e 中所示的类似。

由于大多数地震和余震发生在数十米至数百米宽的低速断层破裂带之外, 它们产生具有较大振幅但较短持续时间的断层导波 FZTW。这类 FZTW 在野外记录的 FZTW 原始数据中占比很大。相对而言, 由发生在断层破裂带深层内的少量地震产生的长持续时间和多个振幅峰值的断层导波 FZTW 在原始记录数据中占比却较小, 因而在分析和模拟野外记录的大量断层导波原始数据时往往会被忽略。此外, 当使用太低截止频率对原始数据进行低通滤波时, 来自断层破裂带深层的具有较高频率的 FZTW 波列尾部可能会被抹去, 因此也可能导致低估断层低速破裂带在地壳中实际延伸深度。

结论与讨论

在本文中, 我们使用三维有限差分模拟研究与断层深度分层相关的多层低速波导 LVWG 的波导效应。数值试验结果表明在分析解释野外记录的断层导波 FZTW 数据中存在的复杂性。FZTW 波列的前部呈现较大振幅峰且频率较低, 很可能是由断层破裂带浅层产生; 而 FZTW 波列的后部呈现较小振幅峰且频率较高, 可能来自速度较快的深层。由多层断层低速波导生成的大振幅, 长波列, 多峰值断层导波 FZTW, 这与我们在南加州莫哈维沙漠兰德斯 (Landers) 兰德斯 1992 年发生 M7.4 级地震和赫克托矿区 (Hector Mine) 1999 年发生 7.1 级地震后记录的断层导波 FZTW 波形基本一致。然而即使震源位于层状断层破裂带之外, 只要震源深度低于浅层底部, 也可以在浅层产生大振幅 FZTW, 但与位于断层破裂带深部相同深度的震源相比, 这些 FZTW 在 S 波后的持续时间较短, PSSP 比值也较小。由于大多数地震发生在几十到几百米宽的狭窄断层带之外, 如果在分析和建模 FZTW 记录时忽略或低通滤波掉发生在断层破裂带深层的少数地震生成的大振幅, 长波列, 多峰值断层导波 FZTW, 则会导致低估断层破裂带的延伸深度。因此仔细分析研究野外实地记录的断层导波 FZTW 的 PSSP 比值, 有助于区分位于断层破裂带内外震源, 从而帮助我们准确取得发震深度的断层破裂带结构。

从断裂力学和动态剖面分析的角度来看, 活动断层破裂带的深度延伸是一个至关重要且具有挑战性的问题。震源深度断层破裂带的三维结构和物性影响地震动态破裂的传播过程和释放的能量分配, 并可能为震源参数和断层辐射震波的上限频率“ $f_{\max}$ ”提供依据, 从而预测地震引起的强地面运动³⁹。最近, Ferry 等人 (2024) 在数值模拟研究中发现, 地震断面周围的岩石破损区虽然随深度增加而变窄并变得更致密。但与普遍的假设相反, 这个狭窄岩石破损区在地震动态破裂传播过程中继续充当能量吸收器发挥其缓冲功能, 通过稳定滑动速率显著影响破裂动力学。此外, 岩石破损区形成也会显著降低破裂速度,

即使对于狭窄的破损区,也会延迟甚至阻止向超剪切速度的转变。

由于断层导波 FZTW 是由低速断层破裂带和高速围岩边界处多次反射相干产生的,因此 FZTW 波列的特征(包括振幅和频率成分)在很大程度上取决于断层的几何形状和物理性质。利用观测到的 FZTW 波列,我们可以准确地提取发震深度震源周围几十到几百米的断层带宽度。通过研究断层辐射震波的上限频率 $f_{\max}$ 能有助于进一步阐明影响地震动态破裂传播过程和能量释放这个挑战性问题。同时,通过分析来自断层深部的 FZTW 波列长期监测发震深度断层破裂带物性和地应力的时间变化,收集的资料用于地震预测。

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中美 IVD（体外诊断）产业发展上的差异

徐一鸣 / Yiming Xu

Becton, Dickinson and Company
120 S State College Blvd #100, Brea, CA 92821

自从中国加入世贸组织 WTO, IVD（体外诊断）业务在中国就持续高速发展，而近年来中国各大 IVD 厂商更是凭借自身在产能，工艺与技术等多方面厚积薄发的优势开始走出国门，在全球市场与美国等传统 IVD 强国直接竞争，而在这个过程中，中国 IVD 企业发现，在中国属于化验科的 IVD 产品在美国却属于病理科这个差异。因此，为了具体分析这个差异极其背后的原因，本文从多个角度进行分析，得出了一个结论。

首先，中美 IVD 具体有何差异：

1. 学科体系的不同

中国的学科分类：在中国，医疗体系通常将体外诊断相关的检验工作归于检验科，也称为临床检验科或医学检验科。检验科的主要职责是通过分析体液（如血液、尿液等）或其他生物样本，进行化学、免疫学、微生物学等方面的检测。检验科与病理科是分开的两个部门，前者负责生化和临床检验，后者则专注于组织学和病理学分析，如活检和解剖。

美国的学科分类：在美国，体外诊断被划归到病理科，这与美国的学科分类和医疗组织结构相关。在美国的医院里，病理科通常包含两个分支：解剖病理学和临床病理学。解剖病理学处理组织学分析（如活组织检查），而临床病理学则涉及实验室检测，包括体外诊断的各类测试，如血液学、微生物学、分子生物学等。因此，IVD 的检验工作在美国被视为病理学科的一部分。

2. 历史发展路径

中国：中国的医学检验学科相对独立，历史上一直是一个独立于病理学的学科。医学检验在中国发展为专门的学科，负责实验室中的生化、微生物、免疫等检验分析，逐渐形成了独立的检验科。这种分科结构在中国医院中得到了延续，IVD 因此归属于检验科。

美国：美国的病理学传统上包括了更广泛的实验室诊断工作，尤其是在临床病理学的领域，涵盖了各种实验室测试。由于 IVD 测试与临床病理学中的实验室检测密切相关，病理科在美国不仅负责解剖病理学的任务，也承担了实验室检验工作。因此，IVD 被认为是病理科的组成部分。

3. 职业角色的差异

中国的检验技师与病理医生：在中国，检验科主要由医学检验专业的检验技师负责，病理科则由病理医生负责。这两类人员的培养和职业发展路径是相对分开的。检验技师专注于体外诊断的技术操作，而病理医生则专注于组织样本的病理分析。

美国的病理学家：在美国，病理学家不仅负责解剖病理学，还负责监督实验室中的各种检验工作，包括 IVD 检测。美国的病理学家通常拥有广泛的实验室诊断知识，涵盖了从组织病理到分子生物学的领域。这种广泛的角色使得 IVD 在病理科中有其合理的位置。

4. 监管和标准的不同

中国的监管结构：在中国，体外诊断设备和检测试剂受到国家药品监督管理局（NMPA）的监管，医院内的检验科负责使用这些设备和试剂进行检测，形成了独立的科室。

美国的监管结构：在美国，体外诊断设备由食品和药物管理局（FDA）监管，然而医院的病理科通常负责这些 IVD 检测的运作和质量控制，尤其是在临床病理学的框架下。这也导致 IVD 在美国的病理科得到更直接的归属。

总结：

IVD 在中国属于检验科，在美国属于病理科，主要是因为两国的医疗体系、学科设置和历史发展路径的差异。中国将医学检验和病理学分为两个独立的学科，而美国则将实验室诊断（包括 IVD）纳入更广义的病理学范畴，特别是临床病理学中。这种不同的分类反映了两国在医学教育、医院管理和职业角色上的差异。

中美两国在 IVD（体外诊断）产品方面存在显著差异，主要体现在市场规模、技术水平、监管环境、临床应用和产品类型等方面。以下是中美 IVD 产品差异的具体分析：

1. 市场规模与增长

中国：中国的 IVD 市场近年来快速增长，主要受到人口老龄化、医疗需求增加和政府推动医疗改革的驱动。中国 IVD 市场的年均增长率相对较高，且国产 IVD 企业正在迅速崛起。然而，与美国相比，中国市场仍处于相对发展的初期阶段，市场渗透率较低，特别是在三四线城市和基层医院。

2023 年中国 IVD 上市企业的营收排名如下：（这些数据仅为 IVD，来自公司年报和百度股市通）

- 1) 迈瑞医疗，2023 年总营收 349.32 亿，其中体外诊断业务 124.21 亿占 35.56%。
- 2) 迪安诊断，2023 年总营收 159.00 亿，其中检测试剂 8.53 亿，占 5.365%。
- 3) 润达医疗，2023 年总营收 112.17 亿，其中流通营收第一。
- 4) 金城医学，2023 年总营收 156.39 亿，其中检验服务 108.18 亿，占 69.22%。
- 5) 万泰生物，2023 年总营收 55.11 亿，其中诊断业务 15.33 亿，占 27.82%。

美国：美国的 IVD 市场是全球最大的，已经高度成熟，市场竞争激烈，且技术水平较高，知名美国 IVD 企业包括丹纳赫（贝克曼库尔特），雅培实验室，罗氏，碧迪医疗（Becton Dickinson）以及生物梅里埃（bioMérieux）等。美国 IVD 产品的应用范围广泛，包括诊断、治疗监控、个性化医疗等多个领域。由于美国拥有完善的医疗保险制度和较高的医疗支出，IVD 产品的普及率较高，市场增长趋于稳定，但仍有创新领域的发展机会。

2. 技术水平

中国：中国的 IVD 技术起步较晚，但近年来技术水平有所提高，尤其是在免疫诊断和生化诊断领域取得了较大进展。然而，先进的 IVD 技术，如分子诊断、基因测序、伴随诊断等高端领域，国产产品的技术水平与国际领先水平仍有差距。许多高端检测设备和试剂仍依赖进口，尤其在大城市的三甲医院中，国外品牌产品占主导地位。

美国：美国在 IVD 技术上处于全球领先地位，特别是在分子诊断、基因测序、伴随诊断、液体活检等前沿领域。美国的 IVD 产品更加注重高精度、个性化和创新性。随着生物技术、人工智能和大数据的融合，IVD 技术正向智能化和自动化发展，推动精准医疗的应用。

3. 产品类型和应用领域

中国：中国 IVD 产品以传统的免疫诊断和生化诊断为主。这些技术在中国的基层医疗机构广泛应用，因其价格相对较低、技术成熟。近年来，随着市场的升级需求，分子诊断和 POCT（即时检验）产品逐渐崭露头角，但其应用仍主要集中在大城市的高端医疗机构。体外诊断在中国的应用还在扩展中，涵盖传染病检测、癌症筛查、遗传病检测等领域。

美国：美国的 IVD 产品类型丰富，尤其是在分子诊断、伴随诊断和个性化医疗方面具有较强的创新性和市场需求。基因组学和蛋白组学技术在美国 IVD 产品中广泛应用，支持个性化治疗和精准医疗。美国的 IVD 产品不仅应用于传统的生化和免疫诊断，还在肿瘤学、感染病学、心血管疾病以及神经疾病等多个领域发挥重要作用。

4. 监管环境

中国：中国的 IVD 产品由 ** 国家药品监督管理局（NMPA）** 监管，近年来中国对 IVD 产品的监管要求逐步加强，特别是在产品的质量控制、审批流程和上市后监管方面。国产 IVD 产品进入市场的门槛相对较低，且政府鼓励国产品牌的发展，但由于监管体系尚在不断完善，部分低端 IVD 产品的质量控制问题仍存在。

美国：美国 IVD 产品由 ** 食品和药物管理局（FDA）** 进行严格监管。IVD 产品在美国上市前需通过 FDA 的审查和批准，特别是高风险的诊断产品需要进行 510(k) 或 PMA（上市前批准）** 的审查流程。美国的监管体系要求 IVD 产品具有较高的临床验证标准和技术规范，因此美国市场上的 IVD 产品质量较高，但上市时间较长、成本较高。

5. 竞争格局

中国：中国的 IVD 市场以国产和进口品牌共存，但进口品牌（如罗氏、雅培、西门子等国际巨头）在高端市场中占有主导地位，特别是在大型医院的实验室中。然而，随着国产品

牌（如迈瑞、华大基因、新产业等）的崛起，国产 IVD 企业逐渐在中低端市场和某些特定技术领域（如免疫诊断和生化诊断）中占据优势。

美国：美国 IVD 市场由全球知名的 IVD 公司主导，如罗氏诊断、雅培、赛默飞、丹纳赫等。这些公司具备强大的研发能力和市场资源，在全球范围内推出创新产品。由于市场竞争激烈，企业不断寻求技术创新和市场扩展，推动 IVD 产品向高端发展。

6. 定价与成本

中国：由于中国的医疗支出较低、医疗资源分布不均，IVD 产品的价格对市场接受度有重要影响。国产 IVD 产品通常具有价格优势，尤其是在中小型医疗机构中，价格较为敏感。而进口高端 IVD 产品价格较高，主要应用于大型三甲医院和特定的高端检测领域。

美国：美国的 IVD 产品定价较高，特别是技术先进的分子诊断和基因测序产品，常与高额的研发和临床验证成本相关。不过，由于美国的医疗保险系统较为发达，IVD 产品的高成本部分由保险承担，使患者可以获得高质量的诊断服务。

总结：

中美两国在 IVD 产品上的差异主要体现在市场规模、技术水平、监管环境、产品类型和定价策略等方面。中国市场正在快速增长，国产品牌在中低端领域有较强的竞争力，但在高端技术领域仍依赖进口产品；而美国的 IVD 市场技术先进、监管严格，以创新和高质量的产品为主，推动精准医疗的发展。

金融文化、伦理和道德风险— 美国的实践与经验教训

陈岳云 / Yueyun Chen

美国洛杉矶西来大学工商管理系

摘要

本文探讨确立金融文化在建立和健全有中国特色金融市场和金融体系,建设中国特色现代化的重要性,并深入分析社会伦理和化解道德风险与践行金融文化的相辅关系。本文特别讨论美国在这些方面的实践与经验教训及中国在构建有中国特色金融文化时,需着重注意和要解决的问题。

金融产业及其发展对个人、企业、社会及整个经济都至关重要。美国金融业附加值占当年整个GDP约8%,共有约九百万从事金融业工作。但金融对经济、社会有其他间接及综合的影响。据估计,金融业创造一个就业岗位,会附带产生3.6个其他行业的岗位。美国的金融业,为美国整个经济活动提供了约72%的资金。美国有世界上最大最发达的金融市场及金融行业,美国证券市场占世界总量的41%,美国的固定收入金融资产规模占世界的40%。而美国GDP占世界的约26%,人口只占约4%。金融业是整个社会的一部分。社会和经济的健康稳定发展是金融业存在和成长的基础。同时,金融业的规模和水平,影响社会和经济的发展水平。美国是最大的经济体,其保险、股票、债券市场也是最大的。中国是第二大经济体,中国的保险业及股票市场也是世界第二。

金融业及金融市场的运行和监管,包括企业及行业的自律和内控,行业的监管,客户、公众及媒体的监督,以及州(省市)和联邦政府机构的监管。建设和实践有效可行的金融文化,主要是金融企业和行业的自律,自我约束。同时,大力建设弘扬金融文化,会提高全民健康的金融知识和素养,从而能更好更有效地发挥金融监督作用。影响金融市场及金融业能否健康稳定发展的,除了经济周期及现状(比如经济衰退期,往往更多的金融问题),金融相关的法律法规及其执行,金融企业本身的因素外,整个社会的文化、价值观及伦理与道德风险的作用息息相关。

金融文化对于规范约束金融业的从业人员,决策方式及决策目的和目标的确立和调整,金融风险的防范,更好服务个人、企业及整个社会和经济,并使金融业自身能健康稳定地发展至关重要。金融文化的核心内容是关于金融的信念、价值观和行为规范。美国虽有系统综合成熟的金融监管体系,但美国金融危机时有发生,特别是重大的金融丑闻事件,包括2006的次级贷款引发的金融及经济危机及像Enron, WorldCom, Arthur Andersen这样的大企业财务作假事件。这些事件和危机,

说明了金融市场和金融业的复杂性和其负面影响的严重性、广泛性和破坏性。这些事件和危机，宣示了企业和行业自律，特别是形成和实践有利自身可持续稳定发展并有利社会的金融文化的重要性。

另一方面，整个社会的伦理和价值观，决定了大众的理念和行为规范及方式。如果整个社会唯利如图，乐于占小便宜，自私而不择手段，金融企业及金融业怎能建立实践健康的企业文化和金融文化。金融服务业的一个关键特性是信息的不对称性。金融业服务的对象，不管是个人、企业或其他实体，掌握实际真实全面的信息，知道自身的风险程度，而金融企业只能根据提供的资料，凭借自己的经验，来判断决定此项业务的风险及相关的决策。所以服务对象的诚实度非常重要。而社会的价值观、伦理道德会影响决定大众的诚实度和诚信率。

金融业的另一个特征，也是影响决定其发展的，是道德风险，人们为了自身的利益，而没有采取必要的措施，而造成了社会的风险和损失。许多金融事件及金融危机，往往是由此道 风险引起的。次贷危机中，房贷借款人，明知自己信用分很低，收入不高，甚至工作不稳定，仍从金融机构借巨款买房，头款极少甚至为零。这样当经济衰退，失业上升时，许多这样的房贷人，无法支付固定的房贷费用，从而违约把房子交给金融机构。另一方面，房贷机构本身也有道德危机问题。他们明知这些房贷人高风险，仍为了短期的业绩和自身直接利益，坦然发放房贷，一方面希望即使经济衰退，高失业率，房地产市场不要大幅下跌，这样把房子拿来拍卖，损失也会有限；另一方面希望若房地产业及金融业遇到困难或危机，政府能出面救助金融机构及整个金融业。当然最终的结果是害己害人损社会，引发了美国金融和经济危机，甚至造成了全球性严重影响。

借贷难是一直困扰许多中国民营企业特别是中小型及微型企业的问题。在中国经济中，中小、微型企业占 99.3% 的全国企业总数。创造了 75% 以上的城镇就业岗位，最终产品和服务价值占约 60% 总 GDP，上缴约为税收总额的 50% 税收。但中小企业从国家银行系统中获得的贷款比例不足整个企业贷款的 30%。民营（私营）企业对新增就业贡献率达到 90%，就业人数占全国城镇就业人数的 80% 以上，贡献全国税收超过 50%，创造的 GDP、固定资产投资以及对外直接投资均超过 60%，民营企业中的高新技术企业占全国高新技术企业的比重超过 70%，但其贷款占整个企业贷款的比例不足 40%。造成中小、微型企业，民营企业借贷难这一持久现象的，除了资源有限，优先服务国家和地方项目及需要，优先服务大中型企业特别是国有企业外，也有金融业的文化因素。民营企业特别是小型及微型企业，经营历史短，资质程度不高，且往往金额小，所以不被金融机构所重视甚至歧视。另一文化因素是怕承担违约的责任。国有单位违约，较能解释及领导或上级主管部门的接受，而为什么与民营企业进行金融交易并造成违约，可能就说不清了。这样多一事不及少一事，就使这些民营企业借贷更不利了。

不同国家因为历史、制度、发展水平等的区别，金融市场及金融业的模式及构成不同。美国作为全球最大经济的国家，有长久历史的最发达最大的金融市场，能吸引国内外广泛的投资、融资。而美国又是一个私有经济占主导的市场经济体。因为这些特性，美国联邦及州或地方政府，靠发行各种债券来直接融资，很少用银行借贷。而且联邦有债务总额上限，州与地方政府有年度预算平衡及举债程序的制约，这样金融市场的政府债券，一般发行及交易较可预期和稳定。

美国只有若干个国有企业，像国家邮政及铁路，其资金主要靠国会每年拨款，极少借贷。这样，

股票市场就是服务私有企业，债券市场就是服务政府机构及私有企业，而银行等金融机构就是服务于民众及私有企业。而且美国股票债券的直接融资比例很高，约占企业总融资的 80%。中国中央及省市等地方政府，除了发行债券融资外，也靠银行提供大量的资金，特别是许多大型项目。而众多国有企业，即使有发行股票及债券，仍依靠银行借款，有的甚至完全靠借贷维持运作。

中国企业直接融资的比例，虽在上升，但仍很低，约为 20-25%。债券市场的融资及银行的贷款，大部分给了各级政府和国营企业。民营企业在经济中占有很高的比例及直接的贡献，但在金融市场是孤儿，弱势群体。要根本改变这一久远的问题，需要从根本上解放思想，大胆改革、创新。中央和省市等地方政府，应主要依靠发行各种债券等来直接融资，逐步减少直至基本消除银行贷款。即使是大的建设项目，也应依靠市场，靠发行债券等来筹集资金。国有企业特别是国有大中型企业，也应借助发行股票及债券直接融资。银行特别是国有银行，通过购买各种债券来支持政府及国有企业。这样的改革，使金融市场发挥了其应用的作用，使金融交易更公平，并能减少公共项目盲目过渡重复投资的现象。更直接的结果是，银行的商业贷款，就会更多地流向中小企业特别是民营企业，从而从根本上解决他们的融资难问题。

美国金融危机及众多的破坏性极大的金融事件，大至有以下的原因：一是经济的起伏特别是经济周期。金融问题大都发生于经济衰退时期；二是金融监管的不到位、不及时、不果断。特别是美国监管，然后反监管，松绑，不断的反复，不仅创造了监管空窗期，有机可乘，更使新的监管更困难，力不从心；三是社会价值观。私有经济，市场经济，崇尚个人自由，反对政府的干预或过度干预，鼓励冒险，以获利为最大或根本目标。这样难免使某些个人及企业，经不起诱惑，挺而走险，游走于法律法规的边缘甚至作假帐，立虚项，谋取短期的私利而毁掉整个企业，造成了严重的社会损失；四是企业特别是上市企业经营的压力。股东期望看到每季度每年好的业绩，投资人盼望股价不断上升。这间接逼使企业主管，采取一切可能的手段；五是所有者-代理人的利益冲突。企业的主要决策人与所有者存在利益冲突。企业主管有任命期限与奖励条款，加上来自投资人对业绩的压力，极易引起企业主管的短期行为和决策，而损害企业的长远利益甚至生存。六是道德风险或道德危机。因为现有的制度及安排，为了个人的利益而不采取必要的措施或手段，防止或避免不利事件的发生。

建设、践行中国特色金融文化的一个重要目的，是预防及避免西方国家时有发生金融危机。金融文化的构建及实施，能解决或缓解上述部分的问题，但很能解决上述主要问题。所以建设中国特色的现代化金融体系，除了确立有中国特色的金融文化之外，还需综合施策，全面治理，有针对性地系统性地了解掌握问题的根源及解决办法。

中国特色的现代化建设，需要各个领域，社会各个方面的全面协调发展。建立健全中国特色的金融市场和金融体系是其中的一个重要方面。而中国特色的金融文化的形成和发展，将是完善提高中国特色金融体系的一个基本要件。在金融文化的建设中，我们不仅要充分理解、容纳中国优秀传统文化和价值观，使之真正具有中国特色，并要学习借鉴其他文化并吸收其他国家金融文化构建中的有效成份及经验和教训，更要与时俱进，掌握现代科技方法和手段，更好地应用于金融决策和金融监管中，从而更好地减少、控制金融风险，提供更好更有效的金融服务。

根据美国在金融文化及金融市场、金融行业发展和监管中的经验和教训，以下几个方面值得中国

注意和借鉴：

经济是金融业发展的基础和根本。经济在增长，企业经营在改善，民众收入更多，金融行业和金融市场就顺利。同时，潜在的金融问题和风险可能正在形成。这时候，金融企业往往放宽要求，发放更多的资金或更多地投资于高风险的金融资产，包括各种金融衍生品。同时，企业和个人也更多的扩展，倾向于更多地借助于金融市场或机构。这样当经济增速下滑，甚至衰退时，企业和个人违约就会大量发生。金融企业不仅有许多呆帐，而且其高风险的其他投资也遭受巨大损失。双重打击下，金融业就产生大的问题甚至发生金融危机。中国特色的金融文化，中国特色的金融监管，就要着重解决、防范这样的行为和问题。

经济周期性的变化及每隔若干年就有经济衰退，是西方经济的普遍规律。中国过去近五十年，经济增长虽有起伏，特别是近年来增长明显减弱，但还没发生过普遍定义下的经济衰退。然后，随着中国经济的持续发展，人均收入达到中等发达水平，经济周期的更大幅度变化，引起经济衰退的风险会显著提高。中国特色的金融文化，中国特色的金融监管，就要着重推迟经济衰退可能发生的时间，防范经济金融危机，缓解危机产生的影响和冲击，更快更好的恢复经济。

诚实守信应该是所有企业，尤其是金融企业的基本原则和信仰，但美国许多保险企业的普遍三Ds做法 -- *delaying, denying, and defending*, 对客户损失所提的赔偿要求，拖延，否决及对此决策的自我辩护，违背了其承诺，不守正道，造成了各种严重后果。中国的保险公司应该避免这种不良做法，中国特色的金融文化应该为不遵循这种做法制定标准和规范。

创新是一个企业，一个行业可持续发展的根本要求。创新是竞争的必然，是建立优势的法宝，是抓住机会的唯一途径。许多美国金融公司在创新和开发产品和服务以满足客户的潜在需求方面表现出色；但往往它们过于创造性和创新性，并产生不可控的风险。例如，保险产品的过度证券化，像引起2008金融经济危机的CDS-信用违约掉期。中国特色的金融文化，中国特色的金融监管，既要鼓励金融企业和个人的创新，更要防止不顾风险的投机行为和具巨大社会破坏性的创新。

金融业大而不倒，政府兜底的想法和做法，是西方金融文化和实践中的一大弊端。中国特色的金融文化，中国特色的金融监管，就要防范这样的思维和做法，从而避免大的金融危机。应该指出，经济周期性变化及经济衰退不可避免，但经济危机特别是金融危机可以防范和避免。

中国特色金融文化构建对中国金融及整个经济的稳定健康可持续发展非常重要。同时也要注意全社会文化道德水平的不断提高及社会伦理的普遍深入人心，广泛践行。更要注重解决金融业内外道德风险问题。只有这样，才能更有效解决金融业发展中的综合性文化问题。

现代化强国的建设，离不开现代化的强大有效的金融体系，特别是多层次高效有序，能及时自我纠错，富有国际竞争力，高度规范的现代化金融市场和金融行业。而构建并践行中国特色的金融文化及其相应制度，是其中的基础和重要方面。中国有悠久的历史，有支撑中华民族历经磨难而不倒的灿烂的文化和珍贵的传统，近五十年改革开放的伟大实践，史无前例的成就及积累的丰富经验和教训，中国人民的伟大智慧，中国人民对实现民族复兴和现代化的强烈愿望和坚定意志，必将能帮助构建并有效践行有中国特色的金融文化。这不仅能帮助中国经济、金融体系的健康稳定发展，亦将是中国对世界文化特别是企业文化领域的特殊贡献。

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舆论法庭：海外华人的共同错误区域

In the Court of Public Opinion: A Zone of Error Shared by Overseas Chinese

Victor Shaw

California State University-Northridge

ABSTRACT

WeChat as the most widely used social media in China provides a platform of communication for overseas Chinese to remain connected to their homeland as well as among one another. It enables them to maintain a court of public opinion wherein to express views, engage in debates, and entertain sentiments. This paper focuses on a zone of error shared by overseas Chinese over the court of public opinion afforded through WeChat. It describes what zone of error is, analyzes how overseas Chinese overreact to issues from China while neglecting matters in their present life, and explains why lacks of involvement coincide with assumptive judgments, groundless assumptions with autocratic personalities, and personal autocracy with reality disengagement. A critical finding is this: The zone of error is an inevitable trap for first-generation immigrants. It takes at least a generation to crawl out of the trap when second-generation immigrants perceive their birthplace as home.

Keywords: Public Opinion; Social Media; Immigrant Entrenchment; Autocratic Personality; Zone of Error; Overseas Chinese

Corresponding author: Victor N. Shaw, Ph.D., is a professor of sociology, criminology, and justice studies at California State University-Northridge. Dr. Shaw is interested in the study of crime, deviance, social control, organizational behavior, higher education, and public policy, and has published widely in those areas. Among the nine academic books by Dr. Shaw, *Substance Use and Abuse: Sociological Perspectives* (2002) appeared in “Outstanding Academic Titles, 2003,” CHOICE: Current Reviews for Academic Libraries, the Association of College and Academic Libraries. *Career-Making in Postmodern Academia: Process, Structure, and Consequence* (2004) topped the list of books to read for graduates and postgraduate professionals by some academic advisors. *Conspicuous and Inconspicuous Discriminations in Everyday Life* (2013, 2015) is the 80th title in the influential Routledge Studies in Social and Political Thought. *Three Worlds of Collective Human Experience: Individual Life, Social Change, and Human Evolution* (2018) is commended by some scholarly reviewers for offering a new paradigm of research on ways of human knowing, acting, and living in social theory. *From Autocracy to Democracy to Technocracy: An Evolution of Human Polity* (2020, 2023) explores three basic forms of government in spatial and time sequences, delineating an evolutionary trajectory for human polity.

INTRODUCTION

Launched in 2011, WeChat has been operating as a multi-purpose vehicle for communication, ecommerce, and social interaction. On a par with Facebook by monthly active users in more than one billion, it makes the Chinese all over the world connected with one another through its social media platform^{1, 6, 8, 14, 16, 24, 25, 32, 34, 35, 36}.

Before WeChat, the Chinese follow the grapevines to share their personal views on current affairs in the shadow of the official media. With WeChat, they find a tangible court of public opinion to entertain their thoughts, positions, and sentiments on issues from work, school, and life to politics^{2, 6, 31}.

This paper studies a zone of error observed among overseas Chinese over the court of public opinion afforded by WeChat. It describes what zone of error is, analyzes how overseas Chinese overreact to issues from their past home of origin while neglecting matters in their present home of life, and explains why lacks of direct involvement coincide with assumptive judgments, impositions of groundless assumptions with autocratic personalities, and exhibitions of personal autocracy with reality disengagement. A critical finding is this: The zone of error is an inevitable trap of discourse for first-generation immigrants. It takes at least a generation to crawl out of the trap when second-generation immigrants begin to perceive their birthplace as home.

CONCEPTS

This paper touches upon a broad issue. To clarify its focus and purpose, some definitional work is in order on three keywords: overseas Chinese, court of public opinion, and zone of error.

Overseas Chinese are Chinese who reside outside Mainland China, Hong Kong, Macau, and Taiwan. By citizenship, they are either Chinese or foreign citizens. Ethnically, they include Hans and Non-Hans, such as Mongols, Tibetans, and Uyghurs. In terms of residency, there are both foreign residents with Chinese citizenship and Chinese residents of foreign nationality^{7, 13, 15, 26}.

The court of public opinion refers to a common domain or public sphere in which individuals express views, exchange ideas, debate issues, entertain sentiments, and share experiences. Inwardly, it spreads across the perceptive consciousness of individual attendees. Outwardly, it traverses through the mass media of social mainstreams. A court of public opinion feature attitudes toward work and professional careers, tips for relationships and everyday life, viewpoints on government and current events, reflections upon fates and human destiny, and thoughts over everything else between life and nonlife, this world and the otherworld, hell and heaven^{9, 10, 21, 28, 34}.

Before the era of social media, a court of public opinion is more of a perceived common field owned by a group of individuals who communicate through the grapevines or around a teahouse, bulletin board, local newspaper, or radio station. It is sporadic and elusive. With WeChat and other social media platforms, communications become spontaneous and constant. Courts of public opinion turn tangible to their participants. Overseas Chinese now feel they share an actual court of public opinion over distance, across national borders and generational gaps. They navigate the court with their characteristic identity, sharing their unique ideas, outlooks, and experiences^{3, 4, 21, 33}.

The zone of error is a range of space where one falls in error with respect to one's view, judgment, or choice. It is relative because it depends upon issue, time, space, and a combination thereof. A view is erroneous on one issue yet being true on another. A judgment proves wrong at one time while turning right at another. A choice appears to be a mistake under one circumstance but seeming to be a correct option under another. There is, of course, an absolute aspect in the zone of error as well. One makes the same mistake again and again regardless of the occasion. People commit the same error collectively irrespective of the time. A zone of error

is characterized as shared by overseas Chinese because it is where they tend to err on issues concerning China, Chinese, and their respective places of sojourn, residency, or citizenship^{12, 22, 29, 31, 38}.

METHODS

This paper follows three WeChat groups of overseas Chinese in the United States in the past five years to study how each group serves as a virtual yet tangible court of public opinion and what zone of error each group falls in as shared by its membership. The author belongs to each WeChat group. He observes member communications by an average level of participation.

Group 1 consists of members who claim a province of China as their common place of origin. Group 2 includes members who call a university of China as their joint alma mater. Group 3 is composed of members who all connect to a university of the United States as its faculty, staff, students, or communal residents.

All three groups are at the official maximum of 500 members. Membership composition seems to be comparable. Age runs a spectrum of 20 to 70. Gender remains balanced between men and women. Education ranges from high school, undergraduate learning, and graduate study to professional training such as medicine and law. Length of stay in the United States varies from year 1 for young students to year 40 for longtime residents. Residency or citizenship involves permanent U.S. residents, non-U.S. residents, Chinese citizens, and U.S. citizens^{19, 20, 32}.

FINDINGS

Members come and go. Postings appear and disappear. Exchanges accelerate and decelerate. Atmospheres fire up and calm down. Indeed, things take place on WeChat both instantly and constantly^{8, 10, 16, 18, 27, 28, 32, 35, 38}.

A Virtual yet Tangible Court of Public Opinion

On WeChat, a group appears real in physical existence. Members literally utter and hear voices across a group-owned collective field. Communications run real as objective phenomena. Participants straightforwardly make and take words over a community-shared common platform.

It is virtual. WeChat gathers individuals in cyberspace. A group consists of hundreds of members under a title with which they become identified. For example, XX university alumni association serves as a sign under which graduates from XX university come for exchange of ideas, feelings, and experiences. One enters a group with one's WeChat name, such as clear water and blue sky, which offers no clue as to who one is. A group hence usually requires its members to identify themselves by real name with information pertinent to the group, including major and year of class in the case of an alumni association. Members obviously do not meet face to face across any concrete space. Nor do they interact in person during any specific time. Yet, they describe things, tell stories, and create meanings as if they were at a definite locality, staying committed to symbolic interaction. They explain events, debate issues, and make senses as if they were in an exact period, remaining immersed in a public discourse.

It is tangible. WeChat connects people to a viewable stage. Unlike printed media serving as a court of certain conservative ideas, it does not make users search a pile of newspapers, magazines, and books for inputs and inspirations. WeChat links people to a perceptible platform. Different from broadcasting channels functioning as a field of some liberal thoughts, it does not force members to tune to a set of radios, televisions, and films for expressions and outputs. WeChat engages people in a feelable circle. As social media featuring exchange of opinions, it gives participants a consciousness that they are in a touchable place, uttering and

hearing voices to and from a resonating audience, a feeling that they are at a conceivable time, making and taking words to and from relatable actors, and an experience that they engage in meaningful communications with palpable players over ongoing social affairs. Indeed, a WeChat group, each member hereof, and everything therein are real, constituting a complete court of public opinion with all necessary elements, from live persons, concrete things, and a peculiar time to a specific place.

Messages

In a WeChat group, messages come and go by a variety of types. Entertained throughout the WeChat court of public opinion are news, stories, advertisements, reflections, commentaries, moral directives, religious teachings, political ideologies, and social advocacies.

WeChat messages vary in terms of content objectivity. Objective messages include diaries to record daily routines, news to report current events, accounts to describe trips, documentaries to feature incidents, commercials to present products, brochures to introduce places, briefs to summarize projects, or stories to cover people and things across a territory or over a period. In comparison, subjective messages involve morality as to what actions and ways of life are moral or immoral, religiosity as to how Allah, Buddha, or God create and guide humans toward their destinies, ideology as to why one type of political economy or system of civilizations is more advantageous than another, and advocacy as to when or where particular social groupings or movements are in order to rise to occasion for promotion or resistance. Obviously, objectivity or subjectivity is not something absolute on its own. It runs a whole gamut from objectivity to subjectivity. In between lies just more or less objectivity relative to subjectivity, vice versa. For example, news report events with both objective facts, such as time, place, persons, and things, and subjective elements, including praises, criticisms, wishes, and damnations.

WeChat messages exhibit different intents with a changing degree of intentionality. Messages of strong intents either advance something or attack someone. Negative messages to attack China, the Chinese Communist Party (CCP), and the Chinese government or vilify Chinese, Chinese bureaucrats, and Chinese leaders top the list with the strongest intent to achieve the highest effect of negativity. To an extent, there are natural motivating factors in the court of public opinion that glorify exposers, criticizers, and attackers as brave, sharp, and critical individuals. Then come positive messages to advance capitalism, democracy, and Western ways of life or celebrate renowned scientists, politicians, or industrialists. To some degree, there are automatic restraining forces in public consciousness that hold admiration and flattery in check because excess makes admirers and flatters look awkwardly uncritical or embarrassingly out of character. In between are regular messages to present individuals, describe things, explain events, or justify actions by varying levels of positive overtones or negative overtures. For example, an album is featured with a positive intent to show how beautiful an artist is in his or her voice. A debate is launched over an incident with a negative intent to show how corrupt officials are across governments in China.

Functions

A WeChat group as a court of public opinion is for members to send and receive information, present and hear ideas, express and entertain feelings. Functions hence range from connecting, sharing, promoting, fundraising, and assistance-seeking to identity-maintaining.

Connecting is basic. Members form a group for connection. They initiate a conversation, respond to an appeal, or remain silent. They may also opt to subgroup communications by forming a smaller cluster or to private dialogues by engaging in one-on-one contacts. Sharing is a norm. Members attend the group so that

they know what succeeds or fails, understand why someone gains attention or loses credibility, and witness how something materializes or turns from positive to negative. They visit the court of opinion to befriend people, gather inputs, and embrace a community while facing challenges, contributing outputs, and cultivating their unique characters. Identity-maintaining is part of any group. The sense of belonging defines who one is, how one compares to others, or why one feels proud of one's identity. In voluntary terms, one jumps onto a group wagon simply because one finds an avenue to enhance one's social standing.

Promoting is purposeful. One puts out an advertisement to sell a product or service. One sends an announcement to introduce some religious practice, a moral way of life, or a module of physical exercise. One spreads propaganda to galvanize individuals around an ideology, a political party, or a social movement. One takes a series of steps to make people commit to an adventure, a cause, or a pursuit. Fundraising goes after money. One pleads for donations with a moving message that someone is struggling upon a surgery. A subgroup organizes a fundraiser for money needed to defrost a fieldtrip or for supply necessary to aid participants of difficulty in an activity. The whole group initiates a campaign to collect funds and materials in a disaster or pandemic relief effort. Assistance-seeking is specific. One asks for information as how to reset a smartphone, where to get a cheap haircut, or when to see a full blossom. One seeks professional advice on work permit application or tax preparation. One solicits ad hoc assistance such as finding an apartment before arrival or looking for sponsorship of an academic visit to a university.

Subjects

In the WeChat court of public opinion, attendees make their exchanges on various subjects. Illustrative of their opposing positions and sentiments are these subjective topics: China, Chinese, East, Eastern civilizations, the United States, Americans, West, and Western development.

Attendees are all Chinese, claiming China in the East as their homeland and the Chinese culture of Eastern civilizations as their heritages. China becomes a natural center of concern. One side embraces China, attributing their rearing to China, feeling excited about good news from China, and taking actions to benefit China. The other side opposes China, attacking the Chinese government as a one party-dictatorship, exposing Chinese officials for abuse or corruption, criticizing China over a range of issues. The "Chinese" automatically falls under the limelight of scrutiny. There are members who regard Chinese as intelligent, diligent, and law-abiding, celebrate Chinese achievements and contributions, and promote Chinese reputations and positions in larger society. There are also members who compare Chinese to other ethnic groups as being less conscientious or contributive, spread news implicating Chinese in thoughtlessness or materialistic greed, or tell stories blaming Chinese for disunity and political apathy. The same holds true to the East and Eastern civilizations.

WeChat members live in America. The United States appears as a central subject. Members in support of it love everything about the country. They admire its political system, from freedom of speech, democracy, and open media to rule of law. They enjoy its economic affluence, reflected in consumer markets, recreational amenities, and sociocultural infrastructures. They feel proud of its leading position in the world, as either the forefront of science or the playground of international relations. Members critical of it point to economic disparity and racial division faced at home as well as aggression and sabotage committed around the globe by the United States. They spread news about violence, political corruption, and homelessness in their jurisdiction. They tell stories documenting their own experiences with racial biases, discriminations against people of foreign origin, or even hate crimes. They blame the United States for wars in countries like Syria, Ukraine, and Yemen. "American" arises as a subjective topic for heated discussion and animated debate. There are feelings of like and admiration. Members like Americans to be open and generous. They love Americans being fair and serious about rules. They admire Americans for their creativity, spirit of adventure, and strive

for self-actualization. There are also sentiments of fear or dislike. Some fear Americans to be manipulative, exploitative, or discriminative. Some holds an unfavorable view of Americans as lazy, talkative, and discursive. Some dislike Americans for their arrogance, indulgence, and materialism. The same applies to the West and Western ways of life.

Objects

Within a WeChat group, members engage in communications over different objects. Featured in their contrasting approaches and attitudes toward objective issues are work, job duties, organizations, life, foods, medicines, and communities.

Working overseas, WeChat members do not usually talk much about their current work, job duties, and affiliated organizations. There are natural concerns that general complaints cause real troubles or unnecessary worries. There are instinctual fears that exposure of specific persons or incidents comes with immediate legal effects or unexpected economic repercussions. There is further a consciousness that an account of negative experiences reflects unfavorably on one as incapable of doing one's job, adapting to one's work environment, and steering one's professional career. The safe take on the matter is to remain silent, even when one excels on job and achieves known successes in one's area of business for just a normal show of personal achievements can be assigned to self-promotion. On the other hand, WeChat members tend to be vocal, critical, and cynical toward their past work in China. Reasons are apparent in terms of time, distance, and substance: It is in the past, with no connection to the present; It is far away in China, with no effect on what goes on in the United States; We know it is bad there, that is why we are here; We understand it is low then because we experience high now. Indeed, it is sufficient to keep a feel of growth and progress at present by looking down upon the past just as it is necessary to maintain a sense of advantage or supremacy overseas by downplaying and denigrating everything back home.

Living in the United States, players over the WeChat court of opinion like to show foods, exchange information about health, and spread news on communities. Compared to work that has to do with an employment organization, life is in one's own hands. Food is a multidimensional object. It reflects a set of living skills and a type of lifestyles. Cooking foods at home reveals one as an able spouse. Dining in restaurants links one to certain social classes. Health draws broad interests. It is about loving, respecting, and promoting life. Loving life, one exercises, engages in recreational activities, balances diets, and maintains positive outlooks. Respecting life, one moderates drinking, refrains from smoking, resists drugs, and keeps self-discipline. Community showcases one's standing in the new society. What neighborhood does one reside in? Does one *get along* with neighbors? Is one familiar with amenities and opportunities available in one's community? All these speak of one's economic conditions and cultural assimilations to the social mosaic of America. Regarding the past life in China, WeChat participants are overall quite reticent. Obviously, one would not like to revisit one's old living experience if one lives now under a situation not so much better than before. One could not make any difference in one's current living by either romanticizing or demonizing one's life back in China. The best is then to forget about the past back over homeland and focus on the present right here in America.

Participants

Members of each WeChat group do not roam just individually in the court of opinion. They gather around topics and issues. They cluster over positions and arguments. When clashes intensify, neutral information is poured in to put out fires. Where subgroups point fingers at one another, a few onlookers only need to crack a joke or yell out a reminder as to what the group is to prevent the situation from further escalation.

Attendees line up to form an army to attack Chinese, China, and things related to both. They usually begin with a lone Chinese, a shopper sorting through a whole box of fruits just to buy one, a housewife stockpiling masks on the eve of the Covid-19 pandemic, or an old man accusing a bystander of pushing him down to the ground who assisted him on the street. A barrage of criticisms and condemnations ensue, creating a narrative of Chinese as if they were all selfish, greedy, and unconscientious. Attackers sometimes kick off by a hearsay or news headline that a factory releases untreated wastes to a river, a group of market inspectors force merchants out of business, or a local government conspired with gangsters to extort peasants within its jurisdiction. Upon a real or fake incident, a wave of debating or bickering expands, engendering a portrayal of China as a backward, lawless, or repressive country. The CCP is certainly both starting and ending points of any negative exchange in the WeChat court of opinion. It is always dealt with the full power of bombardment, especially for its systematic censorship of mass media, all-way surveillance of people, and exclusive control of government. Interestingly, neither a blaze of cursing Chinese nor a burst of attacking China subsides or goes extinct because it meets with opposition by defenders of Chinese or supporters of China. It often takes merely a series of neutral messages on arts, travels, or cuisines to push a tense fight off the court at WeChat.

Participants stand out in rally after rally to glorify Americans, the United States, and issues regarding both. They tend to start off abstractly, by the stereotypical image of the United States as a land of individual freedom, open press, representative democracy, and market economy. When positive events happen, from scientific breakthroughs, technological innovations, and cutting-edge products to state-of-the-art facilities, they are attributed to the institutional supremacy of U.S. civil society, political economy, and cultural framework. Where negative things exist, including racial discrimination, drug abuse, and gang activity, they are brushed off as incidents common to all free societies. About Americans, WeChat members are inclined to tell stories from everyday life. A couple who already have their own biological son and daughter adopt a baby from an orphanage in China. A family serves as a host for Chinese students year after year for free. A stranger helps a Chinese newcomer change a flat tire on a freeway. Case by case, Americans are portrayed to be nice and noble. Incident after incident, Americans are looked upon as law-abiding and responsible. Abusers and criminals seem to be living only in movies. Prejudice and discrimination appear to be of fiction than reality. Noticeably, either beautifying Americans or glorifying the United States does not fade or die as it faces challenges by opposing viewpoints. It usually needs only a sequence of factual postings such as breaking news and event announcements to blow a heatwave of admiration or worship from the WeChat sphere of opinion.

ANALYSES

Inherent in phenomenon, there is logic or a logical connection from place to place and from time to time. Underlying existence, there is truth or a truthful chain of cause and effect. As far as this article is concerned, are there reasons and reasonable themes or pattern above and beyond findings (Shaw 2019; Zhao *et al.* 2019; Kareem and Amjad 2020; Ruan *et al.* 2021; Su and Xiao 2021; Harwit 2022; Zha 2022; Liu 2023; Yang *et al.* 2023; Jordan 2024; Zhang 2024; Xu, Zhao, and Wang 2025; Yan and Schafer 2025)?

Participants

WeChat members differ in their expressions over the court of public opinion. They clash on ideas, sentiments, and attitudes within the communicational sphere of their own group. Analysis therefore is in order regarding membership backgrounds.

Here in the United States, WeChat attendees break down into newcomers vs. old timers, students vs. non-students, business owner vs. non-business owners, employed vs. unemployed, well-off vs. struggling, and other

contrasting categories. Newcomers feel excited about what they see on the surface in their new environment. Greeted warmly, they develop generally positive impressions about Americans. Floating over reality, they embrace a period of honeymoon romance with the United States. Old timers, in comparison, live long enough to know Americans as classmates, workmates, business competitors, or neighbors. They experience things in a sufficient variety, frequency, and duration to understand the United States as a country of prosperity and poverty, freedom and control, generosity and greed, or commonly positives and negatives. Another important contrast is between well-off and struggling members. Well-off ones have stable sources of income, secure fields of professional activity, familiar networks of social engagement, proper channels of communication, and applaudable styles of life. Their struggling counterparts, on the other hand, rush between job and school, stay on and off work, move in and out of places, or constantly face the challenge of making ends meet or just staying afloat in life.

There out of China, WeChat participants originate from anti- vs. pro-China, Chinese, CCP, leadership, and other opposing groups. China antagonists include ethnic separatists who hate China for its rule over their home territories such as Tibet and Uighur, Hong Kong aspirants for autonomy who lament about China's exercise of sovereignty over Britain's former colony, and Taiwan independence elements who advocate for international recognition of China's self-claimed renegade island as a nation-state. CCP opposers go back as far as former members of Kuomintang who lost the rule of Mainland China in 1949 and come as recently as current practitioners of Falun Gong who failed to gain legitimacy in their home country. Foes of specific Chinese leaderships gather opponents from Mao's, Deng's, and Jiang's to Xi's. For example, exiles from Tiananmen Incident on June 4, 1989 remain critical of Deng and Jiang while holding their remembrance to then CCP Secretary General Hu and Premier Zhao. On the side of support, WeChat members love China because it is where they were born and raised. They defend China out of the simple reason that they have parents, relatives, and friends living there. In a similar line, WeChat partakers like Chinese for they themselves are Chinese sharing so many things from language, ways of thinking, and culture to approaches to life. They rally around Chinese as one people due to the basic fact that negative publicity and malicious vilification forced onto Chinese either shower upon or trickle down to themselves as individual Chinese.

Ideological Divides

Players in the WeChat court of opinion cross ideological divides from childhood socialization to youth exploration to adulthood stabilization. On the one hand, they learn and practice communism, socialism, Marxism, Leninism, Mao Zedong Thought, and Deng Xiaoping Theory. On the other, they read and experience capitalism, civil liberties, democratic processes, and market dynamics.

Ideology divides WeChat memberships as it does so among other crowds. Individuals who believe in Marxism are critical of the American society. They eye on America's rampant drug abuse, widening gap between the rich and the poor, and various other social problems such as racial tension and gang activity. With no sight of a U.S. solution to these societal diseases, they solidify their view of China, its pursuit of socialism and ultimate strive toward communism, as not just a viable alternative, but a realistic path toward social order, world peace, and human progress. As far as Mao Zedong Thought is concerned, followers seem to focus more on Mao's hardline yet strategic stand against the United States as an imperialist power than his specific ideas, especially in the present duel between the two countries. The same holds true of Deng Xiaoping Theory. Whenever U.S.-China relations turn confrontational, with confrontation escalating in particular, a considerable number of WeChat members begin to blame China and its current leadership for failing to adhere to Deng's pragmatism of hiding one's capacities and biding one's time. Interestingly, few stay in the middle ground to reconcile communist ideology with capitalism.

Members who advocate for Western ideology spare no effort to criticize China for its aversion of civil

liberty and democracy. They point to the CCP as the culprit in misleading the Chinese with a hollow dream of utopia at the expense of individual needs and rights in the real world. They target the Chinese government over its abuse of power, corruption, and negligence of public welfare to the benefit of social control and bureaucratic sustainability. Pertaining to the core of Western ideology, participants in the WeChat court of opinion cite cases of censorship in which foreign journalists are kept from reporting sensitive events, news briefs are surveyed to weed out unfavorable contents, or investigative journalism is tamed to stay off certain circles of power. They expose incidents of civil rights violations where city residents are forced out of their homesteads to make way for new development projects, peasant workers are given no pays for months of labor on construction sites run by state enterprises, or civilian petitioners are prevented from presenting their complaints to higher levels of government. They even make accusations of abusive, corruptive, or negligent conducts against specific agencies and officials. For example, a county bureau of environmental protection opens one eye and closes one eye to local restaurants using low-quality ingredients or a ranking official engages in love affairs with his unchecked power. Noticeably, almost none likes going between Western ideals and socialism or authoritarianism to please both sides or just not to irritate either one.

Cultural Clashes

Across the WeChat court of opinion, some members express their favors for Western ways of life, emphasizing material conditions, legal regulations, and individual developments. Some state their preferences for Eastern cultures, stressing spiritual cultivation, moral restraints, and self-discipline. The Chinese medicine often becomes an epitome of the East-West contrast.

Eastern cultural practitioners spread teachings on morality and character-building. They exchange lessons for Taiji and martial arts. When news of domestic abuse, drug addiction, or terrorism breaks out, they blame America for its neglect of family and excessive materialism. Awareness of being different from the larger American population gives them a sense of pride as Chinese for leading a unique life with a meaningful purpose. Where stories about a poet leaving the chaotic city to resettle in a primitive forest or a monk stationing at a mountaintop temple to experience harmony with nature are shared, Eastern cultural followers activate their recollection of childhood or adolescence and renew their nostalgia for home and homeness back in China. Consciousness of being identified with Chinese in China grants them a feel of comfort in keeping their signature character and characteristics on the new land of foreignness. Indeed, Chinese, Chinese culture, and Eastern civilizations define who they are, what they do, how they live, and whether they keep their souls, purposes, and meanings while strengthening bodies, making secular pursuits, and attaining material goals.

Promoters of Western cultures know that they live in America and do not need to remind their fellow WeChat members of the importance of observing laws, paying taxes, or keeping distance from colleagues or neighbors on American soil. What they feel obligated to do is to expose some characteristically Eastern ways of thinking for dragging individuals behind assimilation in the mainstream society. For example, the Chinese deem it a virtue to keep things, whether it is mistreatment or discrimination, to themselves. They feel not just fearful but shameful to report issues to the outside or complain unfavorable situations to the upper level. Advocates of Western styles of life understand that they study, work, and live in the United States and do not need to stress to anyone active in the WeChat court of opinion how much influence U.S. institutions, mass media, and social customs wield over his or her thoughts and behaviors. What they think necessary to do is to reveal the weakness of various typically Chinese habits or traditions on behalf of the whole ethnicity. For instance, Chinese workers prefer bringing self-prepared lunches to workplaces and hence miss a natural opportunity to network with colleagues at dine-out over the lunchbreak. Out of their parents' wishes and their own senses of comfort, Chinese men tend to look back home, China, for possible lifetime partners and

therefore give up on a right thing to do, that is, marrying to an American wife, following her to better fusion in the American social mosaic for a deeper American experience of life.

Immigrant Entrenchments

Living away from it, WeChat members like telling and hearing news or stories about their homeland. To the degree that longing for home affects involvement in current affairs, the former becomes a trench. Struggling on foreign land, WeChat participants hesitate to talk about issues or listen to utterances on reality. To the extent that ongoing life is neglected by avoidance, the latter turns into a trap. Immigrant entrenchments therefore feature an excessive recollection of home or the past in combination with an apparent rejection of reality or the present.

There is no doubt that WeChat attendees pay excessive attention to what happens in China. Attention does not matter with like or dislike. Likers spread positive news, such as a Chinese moral model serving poor neighbors selflessly and China providing humanitarian reliefs in impoverished countries, whereas people of dislike roll out negative information, whether Chinese tourists spit in public squares or China persecutes outspoken intellectuals. WeChat members place too much interest in Chinese and China in the form of either support or opposition. Supporters pull favorable headlines, from breakthroughs in science, completion of a massive project, and adoption of new reform measures to launching of a spacecraft while opposers push damaging postings, as scandalous as a high-ranking official keeping dozens of mistresses, as shocking as a state enterprise losing billions of public funds in just one transaction, or as appalling as some private companies selling harmful products. Naturally, good news blow in greater frequency than bad ones across the WeChat court of opinion. Understandably, stories of detrimental effects lead to higher intensity in the minds of both tellers and audiences. Indeed, it calls for some extraordinary amount of courage to expose a case of badness just as it requires some unusual expanse of space to take in an exposed scene of negativity.

It is without question that WeChat players do not attain sufficient involvements in current affairs across America. A lack of involvement manifests in a poor inventory of vocabularies used to describe and explain issues facing the mainstream society. Drug abuse, gun violence, racial tension, and poverty sound remote as they live on a relatively secured enclave of Chinese immigrants. Political campaigning, voting, partisan bickering, and racial empowering look foreign because they have a hard time relating those to what they do in everyday life. Involvement relates to acts and actions. WeChat members share much in focusing on their own businesses, professions, and areas of study or expertise. They stay away from communal affairs, political events, and social activities. As a result, they suffer from not just a general unfamiliarity with vocabularies for, but also a specific non-acquisition of experiences with the real world of America. Psychologically, within the WeChat court of opinion, members are too clever to touch upon issues about the United States, its legal system, economic operation, and political mechanism for they know that errors in presentation expose their inadequacies over surviving in a new country, which they instinctually hate revealing to their fellow associates. They are too smart to discuss matters concerning America, American history, society, and ways of life since they understand that mistakes over exchange exhibit their limitations in struggling to live on a foreign land, which they habitually resist showing to their own people.

Autocratic Personalities

A salient exhibition in the WeChat court of public opinion is autocratic personality. What is it? What features does it show? Are there any realistic factors and forces behind autocratic personality and its display in public sphere?

Personality affects how one thinks and behaves. It determines what one becomes as a person. One with

autocratic personality thinks as if one were an autocrat: One is smarter than everyone else or no one except oneself knows how to think correctly. One speaks like a ruler: You listen while I talk; You utter nonsense whereas I speak truth. One acts as a dictator: You follow my orders as much as I give you commands. One feels one is on top, in the center, and at the right side of reality: Everyone else is down, in the periphery, on the wrong side of history, and therefore can neither say things appropriate nor do things proper. In the concrete, WeChat members assume that they know everything about Chinese and China as they dwell on issues concerning Chinese or China. They tend to imply that Chinese are rude, morally questionable, opportunistic, and not as civilized, professionalized, or openminded as Westerners when they criticize Chinese and Chinese ways of thinking, working, and living. They look inclined to suggest that China is backward, politically secretive, dangerous, and not as modernized, institutionalized, or democratized as Western states wherever they point fingers at China and China's policies, practices, and achievements.

Underlying these autocratic personality characteristics are five important factors or forces. One is about origin. WeChat attendees are Chinese, born to and raised by parents in families of patriarchal tradition. A signature feature of patriarchy is that the patriarch is always right. Another concerns background. WeChat players come from China, a country where one all-powerful party wields firm control of government and the general population to strive for a utopian ideal, communism. The flagship nature of a one-party state is that the party and party leadership can neither be questioned nor challenged. Still another regards reality. WeChat members live on a land where they feel foreign and are treated as aliens. In foreignness, they lose interest to delve into the American mainstream society. It is not uncommon that one says a lot about there and then when one does not know what to tell here and now. With alienation, they seek an outlet to release negative sentiments. It is not untypical that the more one talks about home or past, the more one takes it for granted that one knows all about it even though it becomes more remote. The fourth relates to platform. WeChat is a form of social media. Participants use the media to socialize, vent, or make an impression. Knowing that an audience is there listening yet one does not have to face it, one becomes emboldened to say things extraordinary or even outrageous like a leader, celebrity, or person of influence. The last coincides with opinion. Opinion comes and goes. Sometimes it blows like winds. Sometimes it flushes like waters. To grab attention, one naturally emulates a self-assumed visionary to put forth ideas that draw eyeballs. To leave some impacts, one automatically mimics an ethnocentric preacher to spread messages that stir up minds.

A Zone of Error in Discourse

The most interesting yet significant observation of the WeChat court of public opinion is a zone of error shared by group members. It is identified as a zone because it appears and exists in a court. It is referenced as a zone of error since it involves and invokes errors in thought, speech, and behavior with erroneous consequences.

It is a primary error that WeChat members as immigrants in America do not attend adequately to what goes on around them in workplaces, local communities, and larger societies while putting excessive interests into their past homeland of China. Neglecting current affairs has direct effects. It is likely that Chinese immigrants forgo their due chances for gaining access to social resources. Failing to engage in ongoing activities hold immediate consequences. It is probable that Chinese immigrants miss their rightful opportunities to obtain upward mobilities. On the other hand, attention to the past is meaningless, leading to almost nothing than an escape from reality. Interest in the homeland is useless, resulting in virtually zero than homesickness detrimental to everyday survival. Moreover, attention to the past reinforces neglect of the present just as interest in the former homeland strengthens disengagement from the current real world. The primary error forms a zone of error when WeChat members express ideas, spread messages, exchange stories, and share feelings across

their common court of public opinion.

It is a secondary error that WeChat participants living in the United States think they know everything about China as a faraway homeland over the past while feeling they understand nothing about America in front of them right now. The past fades in memory. Memory can never be so clear and reliable as reality. It is a false consciousness that WeChat members feel they know China well for they used to study, work, and live there or they understand Chinese in China sufficiently since they are their parents, relatives, childhood peers, past classmates, former colleagues, and lifetime friends. The matter of the fact, however, is this: China changes everyday and has changed markedly since any WeChat participants departed; and Chinese in China like people anywhere change all the time and have changed noticeably from years ago when any WeChat members left. In the meantime, the present goes on in experience. Experience is always as fresh and dependable as life. It is a myth-shrouded misperception that WeChat members think they have no ways to comprehend America and American ways of life because they are Chinese or they possess no means to grasp the United States and U.S. laws, economic operations, political mechanisms, social institutions, or cultural dynamics due to the fact they are born and raised in China. Studying in American schools, WeChat attendees know enough about American education, culture, and spirits. Working in American organizations, they understand sufficiently how American labor, civil service, business, and professional community intertwine. Living in the United States, they command adequate knowledge and experience about neighborhoods, communities, local jurisdictions, states, the federal government, and their interrelations. Like its primary counterpart, the secondary error converges in a zone of error where WeChat players entertain words about Chinese, China, East, Eastern civilizations, Americans, America, the United States, West, and Western institutions throughout their joint platform of social media.

CONCLUSION

This paper follows WeChat as a principal social media platform to study overseas Chinese and their communications in terms of form, content, style, and feature.

Upon observation, three unique findings become clear. WeChat gathers Overseas Chinese in one place, bringing them into close contact, not face to face nonetheless emotionally and spiritually. Within a WeChat group, overseas Chinese share information, exchange ideas or experiences, and engage in discussion of subjective matters or debate on objective issues as if they lived in one community as one people. Indeed, WeChat functions as a de facto court of public opinion where overseas Chinese play both instantly and constantly as speakers, storytellers, listeners, questioners, commentators, critics, or just spectators.

Through analysis, three significant features seem worth of notice. Overseas Chinese think too much about their homeland as if they still lived there. They naturally assume that they know anything about Chinese because they are Chinese just as they understand everything on China since they are from China. They automatically feel they have an almost inalienable right or obligation to express concerns, voice opinions, or provide support for matters involving Chinese and China. As a result, overseas Chinese tend to forget that they live outside China. Indeed, they no longer know China as it is now nor understand what Chinese experience currently back in China. Most important, they should focus on themselves, getting to know their new culture, society, and country, and becoming involved in their present workplaces, neighborhoods, and communities. Reflected in these related chains of acts and activities are immigrant entrenchments, autocratic personalities, and a zone of error in social communication.

It is hoped that this paper will open a series of inquiries into China, Chinese social media, overseas Chinese, and immigrant mentality. Unique conceptualizations will spawn fresh interests in research or point

to new directions of study in established fields. For example, a zone of errors over a virtual court of public opinion can shed light over communication studies while autocratic personalities and immigrant entrenchments may inform theorizing in demography, sociology, and political science.

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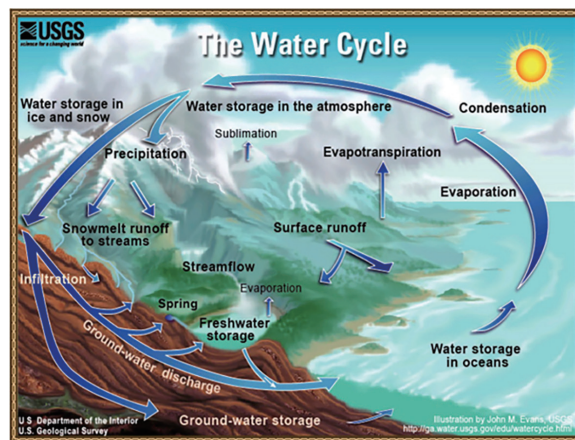
人类资源枯竭 - 地下水资源保护

容跃 / Yue Rong

北京师范大学

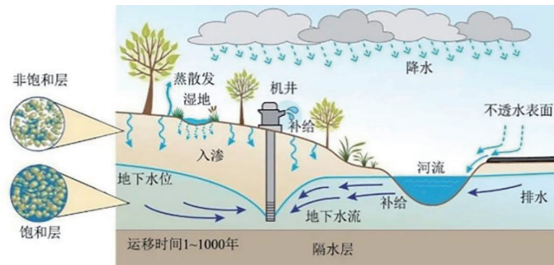
二零二二年三月二十二日定为世界水日，当年主题是地下水。口号是“使看不见的变得看的见”。是的，地下水是一个看不见，摸不着的现象。千百年来，人类从河湖中取水，沿河息居。近年由于水资源短缺，人类开发地下水做为饮用水源。以美国南加州为例，大约 45% 的人类生活供水来自地下水。这一章我们主要来关注一下地下水资源和其问题。

首先，地球上的水是区别与其它星球的标志，也是孕育生命的摇篮。水资源是人类资源最主要的资源之一，因为人类需要以水为生。全球人口从 1960 年代的 30 亿增加到 2020 年的近 78 亿。水资源的需求也相应增加。本来全球水总量 3% 的淡水可足够人类使用。不过由于人口增长和水资源分布的不均衡，生活水准发达和不发达人类群体不同造成的用水过量和不够的矛盾，用水量的浪费，环保节水教育置后等原因，全球水资源枯竭问题突显。水分子由一个氧和两个氢原子组成。水在地球上的分布是以一个水循环的形式运动不息。全球 97% 的水分布在海洋。海洋水蒸发随大气运动到陆地，由降雨雪回到地面，再由河流输送回海洋。这个循环周而复始，永不停息（见图）。图中一般人会不太注意地下水的部分。实际上地下水与地表水是相通的。地下水也是水循环中很重要的一部分。

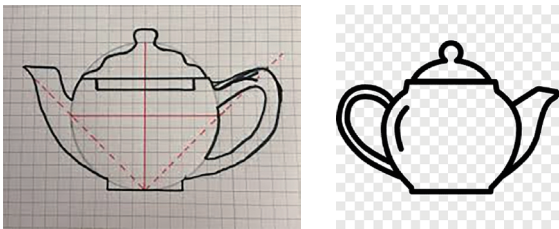


作者简介：容跃博士毕业于北京师范大学地理系环保专业，来美留学获美国加州大学洛杉矶分校 (UCLA) 环境健康科学博士学位。曾任职于加州环保署水质控制管理局洛杉矶分局地下水污染防治和清理处(现已退休)。曾荣获美国环境健康和科学基金会成就奖和美国威斯康星州州立大学 “地球卫士” 奖。容跃博士2024年被纳入UCLA公共健康学院《名人堂》，2025年荣获南加州华人环保协会终身成就奖。容跃曾担任加州大学洛杉矶分校(UCLA)校友会“优秀在校研究生提名委员会”主席。曾当选为南加州华人环保协会会长，南加州中华科工学会会长，南加州高校联盟理事长，UCLA公共健康学院校友会理事，北京师范大学洛杉矶校友会前会长。

地下水是在降水后渗入土壤空隙中的水份。有空隙的地下土层叫作“储水层”。渗入土壤中的水份由重力推动向下运动，直到遇不透水的岩石或粘土层导致蓄水层的出现。蓄水层中的土壤空隙将被水体填满，称作“饱和层”。相对地，如果土壤空隙没有被水完全填满，则称“非饱和层”。因为水往下方渗入，通常饱和层分布在非饱和层之下。在蓄水层中的地下水可由高水位流向低水位并向与地表平行流动。不过这个水流由于土壤中的阻力比地表水流动要慢很多。两者流速可相差几千倍。另外，如图所示，地下水与地表水在水文地质中交错相通。地下水与地表水的互动是由水位的高低决定的。俗话说“水往低处流”。看地表水流动很容易理解，因为我们能看到地形的高低。地下水的流动亦如此，只是我们一般情况下看不到。有时我们在山中可以看到泉水涌出，那就是地下水找到了出口。有时在旅游景区可看到自喷泉，可以冲天射得很高，那是因为地下水的水压高于地表的海拔高度。地下水的压力原理可以用“茶壶水位”的道理来理解。茶壶放平时，壶中的水位总是跟壶嘴的水位一样。如果壶嘴造低，壶中的水就会溢出。下图中显示如果地下水的水位高于地表河流的海拔高度，地下水将流入河床，造成地下水补给地表水。反之，如果地下水的水位低于地表河流，则是地表水补给地下水。图中还显示有一口水井，抽水时地下水就会向水井的方向流动。这样会造成小范围内地下水流向的反转和紊乱。



如果想明白地下水是如何形成的，不妨自己做一个模型。用一个空瓶子装半瓶砂土，然后从上方慢慢撒水，就像下雨一样。观察到水位从瓶底开始上升，形成一个储水层。瓶底是不透水的，就像大自然中的岩石或粘土层。地下水层就形成了。如果再继续加水，地下水层就会上升非常接近地表。如果地下水高出地面，那就是泉水。



地下水资源的问题可以分为两方面。第一是水资源保护，第二是地下水污染清理。

(一) 地下水资源保护

保护水资源就是保护地表水和地下水。因为地下水看不到，保护起来容易被忘弃。地下水的保护措施包括计划开采，估算用量，计算收支平衡。有人说管理水也像管理财政，两者都有流量。入不付出是不可持续的。地下水资源保护规划应包括 (1) 地下水补给地保护，(2) 用水可持续性综合管理，(3) 潜在污染源最优管理，(4) 地下水资源环境保护教育及宣传。

(1) 地下水补给地保护

一般地下水补给地处于山区。平原地区则是自然开旷地。近年来，在干旱地带多有人工圈地作为地下水补给地。以美国南加州为例，因为地处地中海干旱气候带，管理机构以政府行政令的方式要求地方政府兴建土木时要有地下水补给区，例如新房建筑，商业区和市政街道都需要留空间给地下水渗透区。

(2) 用水可持续性综合管理

地下水不是取之不尽的自然资源。用水和补给应该平衡。由于地下水是流动的，管理起来需要有一个区域性的权力机构。地下水使用权通常由法庭裁定。谁有权可以抽水，抽多少。法庭的考量包括谁先在此用水，用水量需求，地下水资源的可持续性，地区发展远景等。另外政府还出台政策鼓励废水清理回灌地下水再利用。

(3) 潜在污染源最优管理

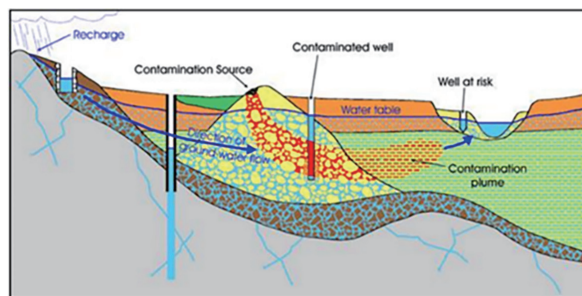
地下水的潜在污染源通常来自地表人类活动，工业，农业，及生活废物。有效控制污染源是上策。先污染再清理是下策。工业，农业，及生活化学物品需要从防渗漏防地表洒漏角度去储存和运输，处理。先期计划以不渗漏为目标。比如建造化学物品专用储存处。应急计划以快速清理回应洒漏事故。比如在场保留清理器具及物品。都要写入日常计划中。

(4) 地下水资源环境保护教育及宣传

地下水是看不见，摸不着。如果被污染也是眼不见，心不烦。所以地下水环境保护教育及宣传至关重要。这就是为什么 2022 年世界水日把主题定为地下水。潜在污染源是可以教育宣传的方式来有效管理，改变生活习惯。当人们了解到科学道理的前因后果就会付诸行动。

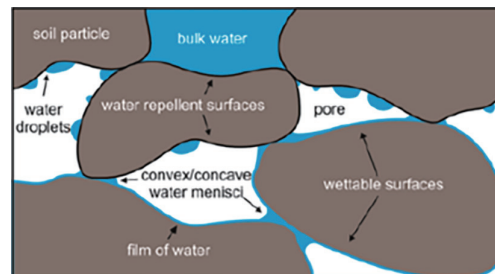
(二) 地下水污染清理

通常地下水的水质是不错的。因为水渗透经过土壤过滤并储存于土壤。不过一旦人为的污染物入侵，污染清理是一个非常艰难的任务。地下水的污染通常来自于地表人类活动。地下水的污染物到达地下水通常是一个慢长的过程。不过一旦污染物到达地下水，从水中清理移除污染物就是一个更慢长的过程。图中红色标示污染物渗入地下后可随地下水流动，污染的范围叫作“污染羽”（或称“污染球”）。污染羽有可能影响水井，也有可能影响地表河流。图中还显示地下土层和水层的地质水文可能是复杂的。

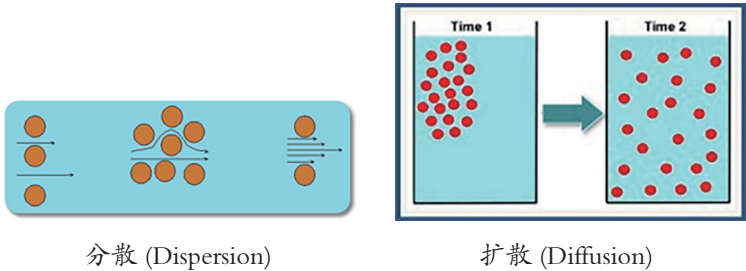


要保护地下水资源要从了解开始。首先要采水样分析。这就要钻井。当钻到储水层时，可装井管插入水层。遇到浅层水可用人工取样器俱。遇深层水则用水泵抽取。装井的最大挑战是面对复杂的水文地质结构和地层。装不好井就出不了水。

地下水污染清理是一个非常困难的任务。为什么呢？首先，地下土壤和储水层由固体颗粒与水与土壤气体合为一体。水和气是流体。土壤中的空隙要么充满水体，要么由水和气共享。其次再看污染物，有可能是固体，有可能是液体，还有可能是气化的状态。另外还有一种叫“非水型液体”像汽油，它不是水，但是液体。当污染物进入地



下后，它的不同物理化学状态与地下不同型态物质（固液气）接触，影响它的迁移转化。污染物可存在于溶解相态 (dissolved phase)，气相态 (vapor phase)，吸附相态 (sorbed phase)，吸附在土壤固体颗粒表面。污染物也许会降解或转化成别的化合物。污染物在地下的迁移包括平流，吸附，分散，扩散，气体挥发，化学和生物转化。分散和扩散的结果非常相似，只是机理不同。分散过程是由于流体（水或气）通过空隙时因为与固体颗粒的摩擦，空隙的大小，流过孔洞的长短所造成的不均匀流程，使物质分散开。扩散过程是根据物质浓度梯度运行的过程。物质总是会从高浓度的地方向低浓度的地方移动扩散开。由于分散和扩散两者过程结果相似，所以多数描述污染物迁移转化的数学模型都把分散和扩散用一个系数代表。



面对这么复杂的局面，如何进行污染清理呢？首先要了解地下水文环境，衡量基本指标包括土壤粗砂，细砂，和粘土成分比例，土壤空隙度，土壤颗粒表面有机碳含量，土壤水份比例（100% 就意味着地下水储水层），地下水深度和流向。另外每年降水量也对污染物的迁移转化很有影响。其次要了解污染物的物理化学性质，衡量基本指标包括水溶度，挥发度，粘稠度，溶点，沸点，分子量，水中比重，氧化还原的潜在程度，厌水性。另外一个指标是微生物品种，数量，和分布。

清理地下的污染物一般分三种方法：物理方法，化学方法，生物方法。

物理方法就是吸抽和挖掘。化学方法就是用化学药物与污染物进行反应而降解。生物方法就是用微生物品种来降解消化污染物。地下水污染清理的原则是截断污染源头，决定污染范围，挑选清理方法，完成清理过程。因为污染源头一般来自土壤，所以地下水和土壤需要一起清理。下面讨论几种清理方法及其优缺点。

(1) 土壤挖掘

土壤挖掘是去除污染土壤并进行处理（图 2）。它是一个快速解决方案，特别适合于即将重新开发的场地。土壤开挖的优点还包括彻底清除污染源区域，并且适用于土壤废气提取或原位注入不能有效工作的细粒土质。土壤开挖的缺点包括成本高、会影响场地运行业务（更适合废弃的空场地）、并且通常不适用于清除深层土壤污染，或建筑物地基附近。最终，挖掘不会破坏污染物，在某些情况下未经处理，只是将其从一个地方转移到另一个地方。

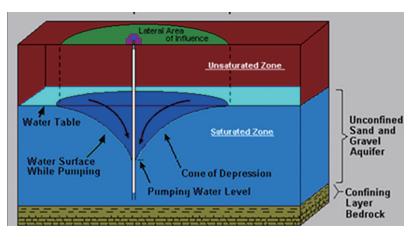


- 总结其优缺点：
- 用于重新开发的快速解决方案
 - 处理精细土壤的更好选择
 - 去除污染源
 - 通常很昂贵
 - 影响场地日间正常业务运行

(2) 地下水抽出及处理

地下水抽出及处理 (P&T) 是将地下水抽到地表进行处理 (图 3)。在地下水被抽到地表后, 可以使用多项物理、化学或生物方法来处理和去除污染物。对于去除六价铬和高氯酸盐等高溶性污染物会更有效。由于地下水现有的溶解污染物被抽走, 从而促进更多的污染物通过扩散和脱离吸附过程而向抽水点迁移来填补浓度空缺。随着修复的进行, 污染物浓度越来越低。处理后的水一般要么排放到下水道系统, 要么重新注入含水层以节约水资源。处理浓度低到一定程度时, 处理每单位水的成本就会增加。如果此时还未达到清理标准, 则这种处理方法的成本效益会降低。这时一般情况下会联合其它清理方法一起来处理。

这种方法的优点包括可以选择多种净化方法来处理特定的目标污染物, 并且对现场业务的干扰较小。缺点是成本高, 排入下水道或地表水可能浪费水资源。处理低浓度污染物也可能不是一个好的选择。

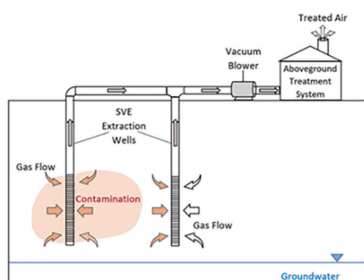


总结其优缺点:

- 允许更多的处理方法选择
- 较少打扰场地日间正常业务运行
- 通常很昂贵
- 如果不回注到含水层, 则浪费水资源
- 对低浓度场地不划算
- 处理系统建设需要大面积

(3) 土壤气吸抽

土壤气吸抽 (SVE) 是利用真空压力将土壤中挥发性污染物的气相吸抽出来处理 (图 4)。它对粗介质孔隙度大的土壤和挥发性污染物有效, 并且可以随着时间的推移连续运行直到完成。费用适中。与地下水抽出及处理方法相似, 土壤气吸抽时, 污染物质量去除率随着处理继续而降低, 停止处理后土壤气浓度时有出现反弹。与地下水抽出及处理方法不同, 土壤气吸抽工艺的处理选项仅限于挥发性有机化合物。常用的土壤气处理选项包括颗粒活性炭 (GAC)、催化氧化和热氧化。提取的土壤气在处理后排放到大气之前需要去掉影响空气质量的污染物, 这通常需要空气质量许可过程, 这可能是土壤气吸抽方法的一个局限。此外, 土壤气吸抽的其他缺点包括它可能在细粒介质土壤中无效, 它通常需要相当大的系统和复杂设备, 并且噪音较大。



总结其优缺点:

- 对粗介质孔隙度大的土壤有效
- 在细粒土壤中效果甚微
- 土壤气浓度可能反弹
- 成本适中
- 需要大面积来建造设备和系统
- 噪音大

(4) 加热处理

加热处理是使用热量来促进污染化合物的挥发性（图 5）。该方法通常与土壤气吸抽结合使用。一边加热，一边吸抽。加热处理方法可以用于饱和带的储水层，亦可用于非饱和带的土壤层。加热处理方法的优点是对土壤气吸抽不能有效工作的细粒土壤有作用，对半挥发性污染物也有效。它的另一个优点是控制温度可加速土壤或地下水的蒸发进而得到清理。加热处理方法的缺点是耗能，因此成本高。对于重新开发计划的场地高需求且资金来源充足的场地，加热处理通常是首选方法。由于土壤介质中的热传输慢，热增加可能仅具有有限的影响区域。

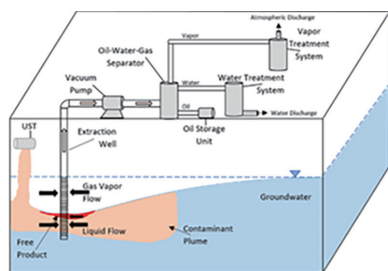


总结其优缺点：

- 适合细粒土壤
- 可处理半挥发性污染物（加热可增强挥发性）
- 控制温度可加速土壤或地下水的清理（缩短总体时间）
- 耗能
- 通常很昂贵
- 影响场地日间正常业务运行

(5) 双相吸抽（多相吸抽）

双相吸抽是指气相和液相被吸抽提取。也可吸抽非水型液体，这样的话就叫作“多相吸抽”。此方法与土壤气吸抽方法相似。有时使用空气注入地下水以促进水中污染物挥发（图 6）。多相吸抽方法的优点是在一个位置清理多相污染物。它对分布在难以清理的水土分界的“虹吸带”污染效果更好。就像土壤气吸抽一样，它可以随着时间的推移连续运行，直到完成清理。其缺点是管道和工程单元系统过于复杂，操作单元占用大量地表空间。如果对污染物在地下饱和层和非饱和层的分布不均匀了解不清楚，它的效果会打折扣。另外噪音大。



总结其优缺点：

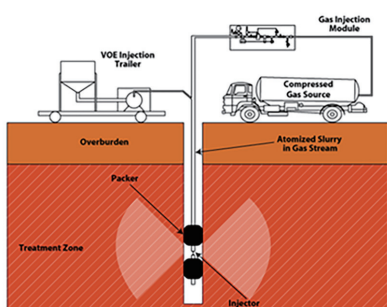
- 可一次清理多相污染物
- 清理水土分界的“虹吸带”污染效果更好
- 成本高
- 工程建设中的系统复杂
- 噪音大

(6) 化学和生物原位注入处理

化学和生物原位注入处理方法是將化学和生物制品混合溶剂注入污染区域，以允许化学或生物过程进行修复（图 7）。对比地下水抽出及处理方法，就地原位注入法的优点是节省水资源。无需将水从含水层中抽出然后再重新注入。它的另一个优点是成本低。原位注入的缺点是难以监测原位注入的效果，可能仅在注入点周围产生非常有限的影响。如果地下水比较深，则注入井的成本就会上升。

作为主要其它物理去除方法之后的后续步骤，原位化学注入方法可以非常有效地降低残留浓度。

然而，这种方法可能无法有效处理浓度非常高的污染羽，例如非水型液体污染羽。生物注入法最大的担忧是向水资源中添加细菌或其他微生物种类。细菌注射不像化学注射剂。停止注入后，化学品最终会在环境中被稀释。然而，对于生物注入，即使在停止注射后，细菌也会成倍增长。有效控制有害细菌生长并让细菌有效地消灭和破坏污染物是一项挑战。我们希望有一种对人类无害，但又能有效修复污染的正确微生物种。同时，也要控制注入生物液剂的规模和数量，以尽量减少对人类的潜在影响，而又能有效地消灭污染物。这无疑是一个技术层面的平衡。

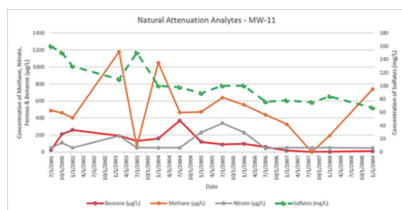


总结其优缺点：

- 低成本
- 较少打扰场地日间正常业务运行
- 节省水资源
- 适合清理后期的跟进修复
- 可能对处理高浓度污染羽效果有限
- 注入的影响区域可能很小
- 比较深的地下水场地会增加注入井的成本
- 监测和验证结果不容易
- 微生物控制问题

(7) 监测自然衰减

监测自然衰减 (MNA) 是通过自然降解的过程而监测到污染物浓度的降低。这是一种非人为主动清理方法。是一种“被动式”的清理。如图 8 所示，自然衰减参数监测并不总是那么简单；有时它不是很清楚的显示。因此，一般应该使用多维参数和证据来判断自然衰减是否确实发生于地下环境中。多维参数和证据包括浓度和质量随时间变化走势（有自然衰减时，浓度应随时间降低）、地球化学参数（例如，二价铁、硝酸盐、硫酸盐等）以及同位素和 DNA 等新技术。另外还应在监测自然衰减的框架内评估污染物的类型、地下环境、最大浓度点及其分布、污染源历史以及对地下污染排放总量的估计。自然衰减法的优点是经济实惠，节省水资源，减少碳排放。有效于人为主动清理的后续阶段，适合于在无法操作或接近的污染场地（例如建筑物下面，无空间运作），或其它人为主动修复方法不见效的情况。缺点是速度慢，可能无法在特定地点的条件下工作，监测结果趋势有时不明显。并且随着时间的推移，监测采样分析可能会变得昂贵。



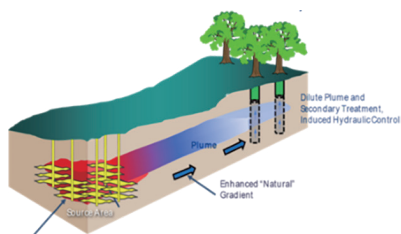
总结其优缺点：

- 低成本
- 节省水资源
- 适合于在无法操作或接近的污染场地
- 有效于人为主动清理的后续阶段
- 较少打扰场地日间正常业务运行
- 监测随时间变化趋势结果可能会很慢

- 难以验证随时间变化趋势结果
- 长时间监测采样分析可能导致成本增加

(8) 植物修复

植物修复方法是使用天然绿色植物在原位去除、降解或分解土壤和地下水中的污染物（图 9）。这种方法更多地取决于物种特异性特征、土壤介质和污染物类型。绿色植物的吸收摄入量可能会区分不同类型的污染物，例如金属或有机物。植物修复的优点是在大多数情况下成本低。节省水资源，减少碳排放。缺点是这种方法可能非常缓慢，清理净化速度取决于季节，难以修复植物根区以外的更深阔污染区域，并且难以监测该方法的结果。此外，高浓度的污染物也许可能对植物造成伤害。

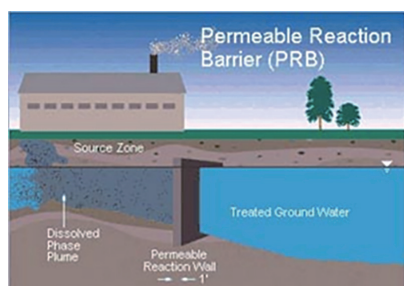


总结其优缺点：

- 节省水资源
- 一种节能绿色技术
- 低成本
- 可能清理过程缓慢
- 不利于清理深层污染
- 种树时影响场地日间正常业务运行
- 难以验证结果

(9) 渗透反应墙

渗透反应墙（PRB）是使用人造渗透材料屏障来处理穿过的地下水污染羽（图 10）。填充在屏障墙中的材料通常包括吸附材料，如 GAC，或原位化学或生物处理材料，如氧化剂还原剂。渗透反应墙处理方法的优点是就地处理可以节约水资源，有效处理迁移的污染羽和被溶解的污染物，尤其是高浓度污染物。与原位注入处理不同，这种方法可能成本高，建筑渗透反应墙施工影响场地正常业务运行。最大的缺点是很难更换和重新填充到位。当阻隔材料被污染物饱和时，修复寿命将无法维持。



总结其优缺点：

- 节省水资源
- 有效处理高浓度和迁移的污染羽
- 成本高
- 建墙时影响场地日间正常业务运行
- 不容易原位更换填充材料

地下水资源枯竭是全球水资源危机的一部分。地下水资源问题要从全球的角度和格局来看待和讨论。应思考我们周围的环境问题和如何重返自然。

近几年来，世界各地的人们开始为遏制气候变化、替代能源等全球环境问题上蓄势待发，共同寻求解决方案，颇有成果。不过，最近这种动静似乎变得有些沉寂了。这不是因为人们不感兴趣，而是

因为环境问题已经进入了一个更复杂的社会、经济和政治篇章。特别是近年受到全球性冠状病毒大流行病的打击和其恢复过程。有点进退两难。现在或许是重新思考和重新评估我们的观点和方法的时候了。

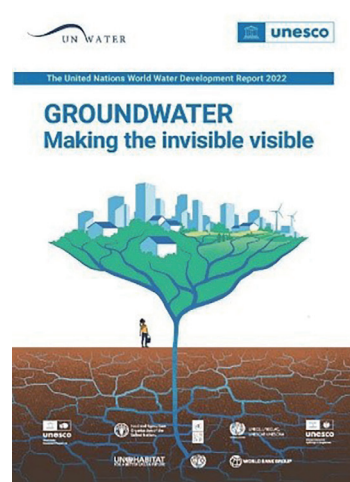
是的。我们是生活在地球上的人类，需要对所有的污染、全球气候变化，病毒流行等负有责任。为了应对这个问题，我们或许必须平衡经济发展和环境保护，以免引起社会冲突和经济动荡。这种冲突和动荡可能会造成更多的环境破坏，例如，1990 年代的海湾战争后留下的海洋石油污染和 21 世纪因地震破坏引起的核电站熔毁和核电站安全争论。面对全球环境危机，人们的本能反应是抢夺先机，这可能会导致人们只顾眼前，不顾将来。最终“欲速则不达”。

中国有句古话，“病急乱投医”。有时，我们认为我们正在做对环境有利而无害的事情，但却忽略了另一方面。例如，我们鼓励大家不要使用一次性餐具，以节约树木和塑料；但是，我们有没有考虑过这样会产生多少废水来清洗可重复使用的餐具呢？当我们为塑料购物袋收取费用以减少环境污染时，我们是否考虑过有多少由聚丙烯制成的“可重复使用”购物袋被丢弃作为难为自然降解的废物处理？当我们使用太阳能电池板将自然能源转化为电能时，我们是否考虑过太阳能电池板制造过程中产生的废水量的增加？我们用的电动车和手机的电池制造也是如此。再比如，我们现在美国的汽油中加入乙醇来改善空气质量，却忽略了使用大量玉米生产乙醇的副作用。这实际上看到的是人和汽车争夺同一种食物的画面。以上所说似乎都可以归咎于一个原因，即人类生活对需求的增加。

在联合国 2009 年哥本哈根气候变迁大会上，一位中国代表认为，中国对解决全球环境计划的最大贡献是其人口控制政策。据他介绍，中国过去 30 年一直在实施计划生育政策而降低出生率，总共减少了约 4 亿人口，相当于减少了约 20 亿吨二氧化碳。从这个角度来看，环境污染和全球性问题可能都能归咎于人类的增长。更多的人意味着更多的食物消耗和更多的能源使用，就像我们上面所说更多的器具、食品袋垃圾，电池，和太阳能电池板。今天，地球上拥有比人类历史上任何时候都多的人口。全球人口从 1960 年的 30 亿增加到 2020 年的近 78 亿。而同期美国的能源消耗增加了一倍多，美国的城市垃圾在这 60 年中增加了两倍多。这些增加无疑会转化为环境负担和损害。

也许正是人类的增长才是我们全球环境问题的主要原因？如果我们不这样看，我们的新努力、技术、能源、资源和新想法可能很快就会被人口更快的增长所冲垮和压倒。但是，如果我们这样看，人口控制将成为宗教信徒之间的社会和政治冲突，就可能会成为阻碍环境保护和解决的障碍。上面提到中国人口控制政策对环境减碳的贡献，不过可惜的是中国在那个哥本哈根气候变迁大会 10 年后改变了其人口控制政策，放宽对出生人口控制，因为中国意识到这样的人口控制对一个社会是不可持续的。

我称这个为人和自然矛盾中进退两难的环境悖论。人类可能是地球上最聪明的生物。他们将并且有权繁殖。然而，有一天，我们可能会耗尽地球上容纳我们所有人的资源和空间，然后我们自己可能会成为邪恶的根源，比如战争。鲁莽的增长和无休止的消费在地球上绝对是不可持续的。因此，现在考虑一个长期解决方案应该与我们目前的环境保护努力相行。解决全球环境问题，必须超越科学领域，



走上政治经济社会舞台。毕竟，环境问题的最终解决方案取决于地球上最聪明的人类。我们如何重返自然？答案是我们要找到人类和自然的平衡点。人类不应与自然争斗，而要重回自然。我们每个都要好好表现，保护环境，节省能源，节制浪费，利用再生。

那么，您今天为环境保护做了什么？

“运气好”的北奥： 机会都是留给有准备的人

韩辉 / Hui Han

中国新闻社·中国侨网记者

“年代可以久远，人身可以老去，可是北京在我们的心中永远不会褪色。那些古都的建筑、流传的民俗、分明的四季、特色的小吃、横竖的胡同……将永远铭刻在我们心中，充盈在我们的脑海里。”美国北京联谊会会长北奥在他主编的《北京故事》序言中如是写道。

《北京故事》是由 75 名海外北京籍华侨华人共同创作，在新中国成立 75 周年之际正式出版。作为该书的主编、作者之一，北奥近日接受中国侨网“华人故事”栏目专访时说，把这些故事写出来，编成书，留给后人是他们这代人不能再拖延的事情了。

从 1983 年赴美留学至今，北奥在洛杉矶生活了 40 多年。如今的他拥有多重身份：建筑预算师、华文作家、美国北京联谊会会长。一路走来，北奥笑言自己属于“运气好”，每当遇到难关时，总会有贵人相助。

留学美国与非裔夫妇结下跨国深情

北奥本名赵杰，祖籍安徽，出生在北京，成长在北京。关于“北奥”名字的由来，简言之，就是得之于 2008 年北京奥运。

1977 年恢复高考后，北奥以优异的成绩进入北京工业学院（现北京理工大学）学习。1981 年，北奥大学毕业后留校任教。1983 年，北奥到美国加州大学北岭分校工程学院学习，他是该校最早一批来自中国大陆的留学生。

“刚到美国时，我身上没什么钱，在美国打工赚钱又不合法。有一段时间，靠吃方便面充饥，结果吃坏了胃。先是高烧不止，然后是胃穿孔，还有皮肤溃烂，有一天上完课后，就晕倒在教学楼外。”北奥回忆说。

那时，工程学院瑞克利夫（Alfonso Ratcliff）院长的太太刚好路过看到，赶忙叫来院长，将生病倒地的北奥送到医院。在医院住院的半个月，瑞克利夫夫妇帮北奥购买了医疗保险。“他们知道我没钱交房租，便将我接到家里暂住，一周后，他俩正式跟我谈话，因为没有孩子，想认我做他们的干儿子。”

原文首发于2024年11月4日中国侨网公众号

北奥说。

瑞克利夫夫妇给予北奥父母般的关爱，还想办法减免了他的学费。后来，瑞克利夫院长还说服校方，一年之内为工程学院 10 多位中国留学生全部减免了学费。

北奥告诉记者，他的“干爹”瑞克利夫是加州大学洛杉矶分校 (UCLA) 第一位黑人博士，也是整个加州大学系统的第一个黑人院长。他小时候家境贫寒，但酷爱读书。那个时候即使在公立学校，黑人也受到歧视，但是不屈服的瑞克利夫总是努力，争取做到最好。

“干妈”瑞克利夫夫人和丈夫一样优秀，她是加州大学洛杉矶分校语言学教授，还是洛杉矶非裔妇女委员会的主席，也是反对对少数族裔歧视的带头人。

北奥告诉记者，后面的日子他就好像是生活在蜜罐里了，别的留学生无法解决的难题和必须面对的难关，到他那里都轻而易举地解决了。

在瑞克利夫退休的晚会上，北奥讲述了他与瑞克利夫这段“中美父子深情”的故事。“我带着全家一起站在台上回忆了 20 多年来瑞克爸爸是怎样帮助我们的，台下来自世界各国的教授和留学生们为之感慨和感动。”北奥说。

瑞克利夫退休后，北奥仍旧对他保持着后辈应有的尊敬与礼节，未曾有丝毫懈怠。随着两位老人日渐苍老，从当医生的妻子，到学医的儿子和女儿，北奥一家开始轮流照顾他们，每月都会看望两位老人，做他们喜欢吃的中餐。

“有一年，我带妻子给年迈的‘干妈’做饭和体检时，这位坚强的黑人女性流下了眼泪。她说，至少我这辈子做对了一件事，就是找到一个中国儿子。”北奥告诉记者，他的儿子和女儿从小叫瑞克利夫夫妇爷爷奶奶，从来不奇怪为什么会有和自己不一样的非裔爷爷奶奶。

北奥说：“‘干妈’的最后两年患上深度老年痴呆症，很多事情都记不清了，可是她却清楚地记得很多去过的中国城市，记得我们是怎样相识和相处的。”2020 年 11 月 27 日，瑞克利夫因病去世，享年 92 岁。“我到美国近 40 年，我们以父子相称了近 40 年。他对我的帮助很大，可谓是恩重如山！”北奥撰文悼念写道。

“北奥”之名从天使之城奥运开始

1984 年，北奥到美国留学的第二年，奥运会在洛杉矶举行。这一年，是中国在恢复国际奥委会合法席位后首次派团参加奥运会，除了 353 名运动员外，还有一支 80 人的官方代表团。

中国代表团抵达洛杉矶前，加州大学北岭分校的几个华人教授发起请愿，邀请中国官方代表团进驻学校。在校董事会议上，瑞克利夫院长也表达了支持，校方最终通过决议。1984 年 7 月，中国奥运代表团第一支队伍 100 多人，全部进驻加州大学北岭分校。

在洛杉矶奥运会比赛期间，代表团每天需要不少车辆将他们分别送往不同的比赛场地。作为中国留学生的北奥，全身心地投入到接待中国代表团的工作当中。

“那些天，我每天开着花几百美元买来的二手车，带着中国记者或代表团成员跑上百里的路。有

时赛事安排比较密集，我们要跑两三个场馆，忙得不可开交。”北奥把这些经历当成了一种难得的幸福。

让北奥最难忘且自豪的是洛杉矶奥运会开幕的第一天，也就是许海峰为中国夺得第一块奥运金牌的那一天。

1984年7月29日，天刚蒙蒙亮，北奥就起来了，吃完早餐后，他开车带着代表团里的体育记者老张直奔150多公里以外的普拉多射击场。

回忆起当时的场景，北奥至今仍心潮澎湃：“我们坐在看台上，目不转睛地盯着许海峰，生怕错过丝毫。许海峰镇定自若一枪接一枪地打，直到最后一枪命中10环。最终，他以566环的总成绩获得金牌，当《义勇军进行曲》在现场奏起，五星红旗冉冉升起，观众席上的华侨华人不约而同地站起来……”

“这天大的喜讯怎么传回去祖国呢？当时的传播方式和技术没有现在这么先进，那个时候，一没传真机，二没有手机，更没有电脑。”北奥拉着体育记者老张到奥运会国际通讯中心附近的一位朋友家借用电话向国内报喜。

“福建人老张念一句，我在电话里用普通话重复一句，一句接一句地向北京发出许海峰夺得第一块奥运金牌的报道。因为报道及时，我还得到当时国家体委的奖励。”北奥说。

在接下来的比赛中，北奥和其他中国留学生到比赛现场为中国奥运健儿加油。喜讯一个接一个，北奥先后见证了李宁夺得三块体操金牌和中国女排首次夺得奥运冠军的奇迹。

1984年8月7日，中国女排夺冠的消息，在美国洛杉矶华侨华人圈引起了热烈的反响。“在庆功会上，我突发奇想，喊出了北京也要举办奥运会并给自己起了一个笔名：‘北奥’——北京的‘北’，奥运的‘奥’。”北奥说，期待有一天奥运会能在我的家乡北京举行，这一畅想引起了很多人的共鸣，“在沉寂了两分钟后，上千人的现场很多人激动地哭了起来。”

和中国奥运代表团在洛杉矶共同奋战的日子，让北奥和郎平、李宁等许多女排和体操运动员结下了深厚友谊，至今他们仍有往来。北奥亲历的洛杉矶奥运会大事小情，后来被他写成了6万多字的长篇报告文学《天使之城的奥运往事》。

专业工程师“跨界”文学创作

毕业后，北奥留在美国打拼。他当过洛杉矶国际机场国际候机楼工程预算的副总预算师，还做过洛杉矶教育局工程部主任。

1993年，联合国针对发展中国家的人才需求，组织了国际工程研讨会到中国培训建筑工程师。北奥听到这个消息后，立即将工作辞去，专心等待联合国的安排。

当时国际先进工程技术都是西方发达国家把持，但这些专家不会讲中文，到中国培训学员面临最大的困难就是语言的沟通问题，北奥的华人身份刚好是国际工程研讨会需要的。

“但即便如此，我第一次参加国际工程研讨会，是以翻译的身份。从第二次开始，我就作为主讲专家，为中国的建筑工程师们授课。”北奥说。

1995年，北奥代表美国公司来到海南，担任美兰国际机场的工程监理。彼时，美兰机场刚刚通过

预算方案，整个机场还是一片黄土地，还处在挖山、填沟、铺设地下电缆的前期，北奥在那里一干就是半年多。

北奥说，1996年，在当时的建设部的策划下，他一共在中国举办了10期国际工程研讨会，培训的学员有上千名。如今，这些工程师大都活跃在中国的建筑工程领域。

专业工程师怎么“跨界”成了作家？

“上大学期间，出板报、做文字编辑、写发言稿，这些工作做多了，我逐渐脱颖而出。”北奥认为机会总是留给有准备的人，虽然在理工类大学，但自己得到了很多写作的机会，锻炼了文笔，为后来文学创作打下了坚实基础。

北奥告诉记者，他的作品可以分为三类。第一类是以回叙方式讲述他所经历的中国故事，即《小英子的故事》《小安子的故事》和《小闻子的故事》。“这些作品呈现特殊年代的青春记忆，在怀旧中体现人与人之间的美好情感。”北奥总结说。

其次，是对中美关系或中美交流相关事件的记述，最具代表性的就是《天使之城的奥运往事》。北奥以见证者、参与者、旁观者的角度对1984年洛杉矶奥运会进行多方位再现，重现历史图景的过程也是他表达自我情感的过程。

第三类是以观察者的角度表现他对现实中国、生活美国的感受和体验，在冲撞和对比中开启思考的空间。

2017年，北奥担任洛杉矶华文作家协会会长。对于担任会长，他说，一个时代有一个时代的精神，一个时代有一个时代的作品，希望能让更多人通过华文作家的作品了解中华文化。

旅居美国40多年，年近古稀的北奥如今仍坚持工作、坚持写作。从形式来看，他的语言表达、写作方式较为自由，更贴近日常生活的本然状态，作品兼具美式幽默和浓厚的京腔京味。

从创立“橙县春晚”到主编“北京故事”

北奥不仅是工程师、作家和诗人，还是合唱团团长，他主办过连续近二十年的洛杉矶橙县华人春晚。

春节是中国人一年之中最重要的日子，春晚是全球华侨华人过春节必备的精神食粮。北奥告诉记者，说是“春晚”，其实就是一开始几十个熟悉的朋友，在自家车库，凑在一起做年夜饭表演节目。

第二年，100多人租了一间学校教室，自弹自唱、自娱自乐；第三年，200多人，还邀请了郎平前来参加；第四年，有了自己的导演和舞美，人员也达到300多人。在北奥的策划下，“橙县春晚”办得一年比一年好。到2016年，来自中国国内艺术团的专业歌手也前来助阵。中国驻洛杉矶总领馆、侨界领袖纷纷到场，参加这一年一度的华侨华人大聚会。

由于出色的组织能力，北奥担任过洛杉矶多个华侨华人社团和专业机构的负责人。2022年，美国北京联谊会换届，北奥当选为会长，今年10月，他连任该会会长。

“除了日常工作以外，我还能在北京联谊会做些什么？”北奥思索后，决定出版一本《北京故事》。凭借着此前担任华文作家协会会长的经验和人脉，北奥很快组织好编辑团队、联系出版社。同时，他邀请中国作家协会原副主席高洪波、北京联谊会总顾问郎平为该书写序言。

北奥介绍说，《北京故事》来稿中不仅有北京籍的在美华侨华人，也有在世界各地的北京人，还有不少的非北京籍，但在北京生活、工作过，对北京有着深厚情感的海外华侨华人。

《北京故事》的开篇几篇文章，有著名侨领张素久回忆 75 年前她在天安门广场参加开国大典的故事，申玉明写的《府学胡同小学》回忆了他在北京的小学生活，许承武的《中关村今夕》回忆他见证北京中关村的崛起和发展。

“75 个北京故事表达了海外游子的情感，唱出了在皇城根脚下长大北京人的赞歌，献上了他们对故乡无限的爱。”北奥说。