Vesicular drug-delivery systems as theranostics in COVID-19

Saurabh Satija‡,1,2, Meenu Mehta‡,1,2,3, Mousmee Sharma4, Parteek Prasher5, Gaurav Guptal, Dinesh K Chellappan*7,8 & Kamal Dua**1,3,8,9

1Discipline of Pharmacy, Graduate School of Health, University of Technology Sydney, Ultimo, NSW, 2007, Australia
2School of Pharmaceutical Sciences, Lovely Professional University, Phagwara-144411, Punjab, India
3Centre for Inflammation, Centenary Institute, Sydney, NSW, 2050, Australia
4Department of Chemistry, Uttaranchal University, Dehradun, 248007, India
5Department of Chemistry, University of Petroleum & Energy Studies, Dehradun, 248007, India
6School of Pharmacy, Suresh Gyan Vihar University, Jagatpur, Mahal Road, Jaipur, India
7Department of Life Sciences, School of Pharmacy, International Medical University, Bukit Jalil, 57000, Kuala Lumpur, Malaysia
8School of Pharmaceutical Sciences, Shoolini University, Bajhol, Sultanpur, Solan, Himachal Pradesh, 173229, India
9Priority Research Centre for Healthy Lungs, Hunter Medical Research Institute (HMRI) & School of Biomedical Sciences & Pharmacy, University of Newcastle, Callaghan, NSW, 2308, Australia

*Author for correspondence: Dinesh_Kumar@imu.edu.my
**Author for correspondence: Kamal.Dua@uts.edu.au
‡Authors sharing first authorship with equal contribution

“Vesicular drug-delivery systems have been progressively employed as co-delivery tools for personalized theranostics that combine diagnostic, prognostic therapeutic and image-guided therapeutic effects”

First draft submitted: 8 May 2020; Accepted for publication: 4 June 2020; Published online: 26 June 2020

Keywords: COVID-19 • theranostics • vesicular drug delivery
Vesicular drug-delivery systems have been progressively employed as co-delivery tools for personalized theranostics that combine diagnostic, prognostic therapeutic and image-guided therapeutic effects [10]. Multifunctional- and multimodality-based theranostic techniques that employ vesicular drug-delivery systems are urgently needed to be developed for simultaneous imaging of the COVID-19 etiology. Vesicular-delivery systems provide a flexible framework in which different diagnostic agent types could be effectively transported. These nanostructures composed of liposomes, polymersomes, nanoparticles such as gold nanoparticles and peptide-based vesicles have potential therapeutic properties that are essential for the development of effective nanomedicines [11–14]. In addition, it is well reported that nanomedicine formulations such as extracellular vesicles might improve the activity of antiviral medicines. The fate of such encapsulated drugs may also be affected by nanoparticles, which allow controlled release kinetics, enhanced bioavailability, improved pharmacokinetics, reduced side effects and maximal patient compliance [15].

Furthermore, the unique physicochemical properties of nanocarriers could assist in targeting specific sites that could enable interaction with viral structures. Nanomedicines are also reported to possess the ability to enhance the antiviral therapeutic index [16,17]. To introduce this innovative approach at the clinical level, certain factors namely quality, impact on health and manufacturing issues have to be carefully evaluated [16]. In the medical sector, the applications of vesicular-delivery systems will prove to be very promising, especially in the development of new therapeutic and diagnostic approaches to COVID-19 [18]. Theranostics with vesicular-delivery systems can further offer innovative solutions to combat future coronavirus outbreak.

Currently, there are no specific antiviral treatments that are available for COVID-19. However, previously developed medicines for the treatment of other viral infections along with several anti-malarial drugs are being tested for their efficacy against COVID-19 virus. As stated earlier, clinical studies are underway to determine the effectiveness and safety of several drugs such as chloroquine, arbidol, remdesivir and favipiravir [19]. As a futuristic approach, these drugs can be used with vesicular-delivery systems with a theranostic strategy in developing novel COVID-19 treatment regimens.

Conclusion
As the epidemic continues to spread, researchers worldwide are actively researching on drugs that could be successful in the battle against COVID-19. Currently, there are no clinically confirmed antiviral treatment options. However, several drugs are now being clinically tested like chloroquine, arbidol, remdesivir and favipiravir that can be targeted with the application of theranostics embedded into vesicular-delivery systems. The effectiveness, preciseness and safety of such advanced technologies have been documented before, nevertheless, further preclinical and clinical trials would validate the applications of these techniques in the treatment of COVID-19.

Financial & competing interests disclosure
The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

References
1. Singh Y, Gupta G, Satija S, Pabreja K, Chellappan DK, Dua K. COVID-19 transmission through host cell directed network of GPCR. Drug Dev. Res. doi.org/10.1002/ddr.21674 (2020).
2. Singh Y, Gupta G, Satija S, Negi P, Chellappan DK, Dua K. RAAS blockers in hypertension posing a higher risk towards the COVID-19. Dermatol. Ther. doi.org/10.1111/dth.13501 (2020).
3. Gupta G, Singh Y, Kumar Chellappan D, Dua K. New emerging dermatological symptoms in coronavirus pandemic. J. Cosmet. Dermatol. doi.org/10.1111/jocd.13466 (2020).
4. Zu ZY, Jiang Di M, Xu PP et al. Coronavirus disease 2019 (COVID-19): a perspective from China. Radiology doi.org/10.1148/radot.2020200490 (2020).
5. Zhao W, Zhong Z, Xie X, Yu Q, Liu J. CT scans of patients with 2019 novel coronavirus (COVID-19) pneumonia. Theranostics. 10(10), 4606–4613 (2020).
6. Wang M, Cao R, Zhang L et al. Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) in vitro. Cell Res. 30, 269–271 (2020).
7. Wu YC, Chen CS, Chan YJ. The outbreak of COVID-19: an overview. J. Chinese Med. Assoc. 83(3), 217–220 (2020).
8. Kooraki S, Hosseiny M, Myers L, Gholamrezanezhad A. Coronavirus (COVID-19) outbreak: what the department of radiology should know. *J. Am. Coll. Radiol.* 17(4), 447–451 (2020).

9. Chen Z, Zhang Z, Zhai X et al. Rapid and sensitive detection of anti-SARS-CoV-2 IgG using lanthanide-doped nanoparticles-based lateral flow immunoassay. *Anal. Chem.* 92(10), 7226–7231 (2020).

10. Li C, Wang J, Wang Y et al. Recent progress in drug delivery. *Acta Pharm. Sin. B* 9(6), 1145–1162 (2019).

11. Mohammadi M, Taghavi S, Abnous K, Taghdisi SM, Ramezani M, Aliaboliandi M. Hybrid vesicular drug delivery systems for cancer therapeutics. *Adv. Funct. Mater.* 18(6), 1802136 (2018).

12. Sharma P, Mehta M, Dhanjal DS et al. Emerging trends in the novel drug delivery approaches for the treatment of lung cancer. *Chem. Biol. Interact.* 309, 108720 (2019).

13. Mehta M, Deeksha Tewari D et al. Oligonucleotide therapy: an emerging focus area for drug delivery in chronic inflammatory respiratory diseases. *Chem. Biol. Interact.* 308, 206–215 (2019).

14. Gold-coated nanovesicles for drug delivery applied to rapid COVID-19 testing – NMZ (2020). www.nanomedzone.com/covid-19-gold-coated-nanovesicles-for-rapid-covid-19-testing/

15. Kumar S, Zhi K, Mukherji A, Gerth K. Repurposing antiviral protease inhibitors using extracellular vesicles for potential therapy of COVID-19. *Viruses* 12(5), 486 (2020).

16. Lembo D, Donaldisio M, Civra A, Argenziano M, Cavalli R. Nanomedicine formulations for the delivery of antiviral drugs: a promising solution for the treatment of viral infections. *Expert Opin. Drug Deliv.* 15(1), 93–114 (2018).

17. Tatara AM. Role of tissue engineering in COVID-19 and future viral outbreaks. *Tissue Eng. Part A.* 26, 9–10 (2020).

18. Itani R, Tobaïqy M, Al Faraj A. Optimizing use of theranostic nanoparticles as a life-saving strategy for treating COVID-19 patients. *Theranostics* 10(13), 5932–5942 (2020).

19. Dong L, Hu S, Gao J. Discovering drugs to treat coronavirus disease 2019 (COVID-19). *Drug Discov. Ther.* 14(1), 58–60 (2020).