Nanomedicine: not for the developing world?

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Because malaria pathophysiology is so complex and the disease is so widespread, it is generally accepted that to achieve eradication a combination of tools targeting the parasite and/or mosquito will be needed (*1*). These include the improvement of existing approaches and the development of new ones (*2*), with drug therapy remaining the mainstay of treatment and prevention to target the parasite reservoir (*3*), and nanotechnology being able to provide innovative useful strategies (*4*). Encapsulation of drugs in targeted nanovectors is a rapidly growing area with a clear applicability to infectious disease treatment (*5*), and pharmaceutical nanotechnology has been identified as a potentially essential tool in the future fight against malaria (*6, 7*). The application of nanotechnology to malaria has been traditionally neglected; the reasons for this gap in nanomedical research are surely varied, but among them are the lack of interest of a profit-seeking industry and the timid support of public administrations to small groups working off the main path of developed world diseases. However, the implementation of novel delivery approaches is less expensive than finding new antimalarial drugs and may optimize the rate of release of current and novel compounds (*8*). An essential aspect for the successful development of antimalarial nanomedicines resides on the choice of encapsulating and targeting elements, which need to be tailored and optimized for their biocompatibility, cell specificity, binding affinity, ease of modification and conjugation to the drugs, production cost, scalability, amenability to oral administration formulation, and stability in mass production. The three elements that constitute a targeted therapeutic nanovector (nanocapsule, targeting molecule and the drug itself) can be exchanged, as if they were LEGO parts, to obtain new structures better suited to each particular situation.

Targeting agents for future malaria medicines can consist of cost-efficient heparin-like molecules, or may even be substituted altogether by self-targeting polymeric structures. These, after delivering their active cargo to target cells, can have an up to recently unsuspected second life as vaccination adjuvants. Drug delivery does not necessarily have to be to parasitized red blood cells, but can be engineered to prefill the more easily druggable uninfected erythrocyte. Finally, the design of antimalarial nanomedicines directly administered to mosquitoes and targeted at malaria parasite stages exclusive to the insect might spectacularly reduce costs and bench-to-treatment time because in this way clinical trials could be significantly simplified.

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References

1. R. G. Feachem, A. A. Phillips, G. A. Targett, R. W. Snow, *Lancet* **376**, 1517 (2010).
2. P. L. Alonso, *Int. Microbiol.* **9**, 83 (2006).
3. J. P. Daily, *J. Clin. Pharmacol.* **46**, 1487 (2006).
4. R. Duncan, R. Gaspar, *Mol. Pharmaceutics* **8**, 2101 (2011).
5. P. Urbán *et al.*, *Curr. Drug Targets* **13**, 1158 (2012).
6. N. Kuntworbe, N. Martini, J. Shaw, R. Al-Kassas, *Drug Dev. Res.* **73**, 167 (2012).
7. P. Urbán, X. Fernàndez-Busquets, *Curr. Med. Chem.* **21**, 605 (2014).
8. P. Murambiwa, B. Masola, T. Govender, S. Mukaratirwa, et al., *Acta Tropica* **118**, 71 (2011).