

Making MAGIC: how to improve the use of peripherally inserted central catheters

Vineet Chopra 

Internal Medicine, University of Michigan, Ann Arbor, Michigan, USA

Correspondence to

Dr Vineet Chopra, Internal Medicine, University of Michigan, Ann Arbor, MI 48109, USA; vineetc@umich.edu

Accepted 13 March 2020
Published Online First
27 March 2020

At this very moment, somewhere in the world, an intravenous catheter is being placed in a hospitalised patient. Whether the device is small and being placed in a vein in the arm (eg, peripheral intravenous catheter) or large and inserted into a great vessel within the chest (eg, implanted port), they share several characteristics. First, they are all designed to deliver potentially life-saving therapies such as antibiotics, fluids and nutrition or blood products. Indeed, safe and reliable venous access is a cornerstone to medical care in the 20th century. Second, in order to access the venous network, they must penetrate through the skin to provide a pathway to the bloodstream. Consequently, they each carry a risk of both infectious and non-infectious complications. Thus, to keep patients safe, selecting the most appropriate device—one that balances risks against benefits—is paramount to ensure optimal outcomes.

While this statement may seem obvious, evidence suggests that clinical practice is far from this ideal. For example, in a study of hospitalised children who received peripherally inserted central catheters (PICC), a large proportion experienced multiple PICC insertions, short dwell times (eg, PICCs placed for difficult venous access) and premature removals (eg, because of failure or lack of clear indication), increasing the risk of harm.¹ In another study of hospitalised adults, patients with PICCs were found to have multiple days where the device was not used, exposing patients to complications without therapeutic benefit.² These aberrations in best practice are not unique to PICCs. For instance, in a global study examining patterns of peripheral intravenous catheter use, two-thirds of all surveyed devices were placed in a non-recommended site, had signs and

symptoms of malfunction or were idle without a clear indication for continued use.³ Similarly, despite the risk of thrombosis associated with PICCs in patients with cancer,^{4 5} many such patients continue to receive chemotherapy through such devices when safer alternatives are available.^{6 7} And finally, while it is well known that patients with chronic kidney disease should not have devices inserted in arm veins to preserve these veins for dialysis,⁸ reports of this continue to permeate the literature.⁹ Why, then, does practice related to vascular access not align with evidence?

While a definitive answer to this question remains elusive, several explanations are plausible. First, when it comes to vascular access, no formal curricula or educational materials for physicians in training exist. Thus, although physicians are most commonly responsible for ordering the insertion of these devices, they are often the ones with the least knowledge related to risks and benefits of device types. Second, there is no defined owner when it comes to choosing an intravenous catheter; instead, surgeons, anaesthesiologists, radiologists, medical physicians and subspecialists such as oncologists and critical care physicians make these decisions based on existing practice patterns and cultural norms. Third, the evidence base for choosing the appropriate intravenous catheter remains weak with very few randomised trials and systematic reviews available to guide practice. As a result, little progress has been made in improving the science of vascular access.

These challenges represent the motivation behind creating the Michigan Appropriateness Guide for Intravenous Catheters (MAGIC).¹⁰ The aims for MAGIC were severalfold: to develop an



► <http://dx.doi.org/10.1136/bmjqs-2019-010463>



© Author(s) (or their employer(s)) 2020. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Chopra V. *BMJ Qual Saf* 2020;**29**:879–882.

approach that encompassed all available evidence to inform decisions related to vascular access; synthesise diverse views from a broad range of stakeholders including device inserters and clinical end users; provide clinical guidance for the most common indications for vascular access across a broad range of devices; and finally, provide a structure to facilitate benchmarking of practice and outcomes. A panel of 15 experts used the RAND/UCLA method to structure recommendations for the most appropriate intravenous catheter according to the nature of the infusion (irritant/vesicant vs peripherally compatible), the medical indication for the device and the proposed duration of therapy. To promote uptake, key takeaways were summarised for stakeholders including intensive care practitioners, hospital providers and vascular access teams.^{11–13} In order to make MAGIC useful at the point of care, we created an iOS and Android MAGIC app—a tool that makes the recommendations within MAGIC actionable at the bedside by answering five questions.¹⁴ Thanks in part to these dissemination strategies and the void in practice, MAGIC has diffused widely. Today, nearly every US state has a hospital or health system that uses MAGIC as their policy or evidence-based resource for vascular access. Similarly, evaluations of MAGIC have shown that implementation is associated with reduction in harm and complications.^{15 16} And countries outside the USA have also started to adopt MAGIC for making decisions regarding intravenous devices.

Perhaps due to these efforts, this edition of *BMJ Quality and Safety* includes a report from Canada assessing appropriateness of PICC use according to MAGIC.¹⁷ Using administrative data sets from five major Canadian teaching hospitals, Verma and colleagues¹⁸ examined patient characteristics, comorbidities, International Classification of Diseases 10th Revision codes, radiology, laboratory and medication data from 101 660 admissions and 3479 PICC insertions to assess whether PICC use was appropriate, inappropriate or uncertain. They report that only 53% of all placements could be classified as appropriate according to MAGIC. The remaining insertions were either inappropriate or of uncertain appropriateness. Importantly, even in a small sample of five hospitals, substantial variation in rates of inappropriate use was observed, with the odds of inappropriate placement significantly greater at one site compared with others. The findings of Verma and colleagues are eerily similar to those of a pre-MAGIC era in the USA,¹⁹ where many inappropriate PICC insertions occurred in patients with advanced kidney disease.²⁰ Additionally, many PICCs in the study were inappropriately placed for short durations in patients who are critically ill, a practice discouraged by infection control guidelines and by MAGIC.²¹ Sadly, Verma *et al* found that the sicker the patient, the greater the odds of inappropriate

placement. Taken together, these data are a powerful lens to evaluate PICC practices using administrative data.

It is important to acknowledge some of the limitations of this work. First, certain variables were not available to assess all aspects of appropriateness. Second, for some appropriateness recommendations such as frequent phlebotomy, MAGIC does not provide a preference or appropriateness rating of one device over another—limiting the ability to classify these use cases. This remains a limitation of MAGIC, as evidence to guide decisions in patients who have difficult intravenous access or need frequent phlebotomy remains scant. Third, data on date of device removal were not available, leading to incomplete estimates of catheter dwell time. Notably, the authors assumed conservative measures in this regard, biasing estimates of inappropriate use towards the null. It is thus important to note that this report is a ‘best case’ scenario—where for more than half of all PICCs placed, concerns about appropriate use exist.

The work by Verma and colleagues should be commended as the first report of operationalising MAGIC using administrative data. It is important to also recognise that their findings closely mirror findings from other deployments of MAGIC, suggesting a high-degree external validity. What is unique about their paper is that the authors have devised a way to assess appropriateness using routinely collected data, thus eliminating the human capital that has otherwise been necessary to evaluate PICC use. To this end, their approach provides a platform to introduce additional techniques such as natural language processing to ‘read’ electronic medical records and enhance data collection. This work also moves us tantalisingly closer to real-time electronic assessment of appropriateness of PICC use. Developing electronic templates for PICC insertion and removal with decision support based on discrete data fields thus appears to be around the corner. With the proliferation of electronic medical records and computerised physician order entry, we are confident that MAGIC can soon provide guideposts for ordering clinicians in ways previously not thought possible.

These strategies are emblematic of some of the approaches we are currently testing across the Michigan Hospital Medicine Safety Collaborative—a quality consortium of Michigan hospitals aimed at improving PICC safety and outcomes. For example, order sets, policies, practice guidelines and workflows from partner hospitals are actively shared between hospitals for adaptation and implementation.¹⁶ We have also actively engaged PICC inserters into the process of vascular access decisions. In most US hospitals, PICCs are inserted by trained vascular access nurses, providers who have procedural competency and insight into the evidence related to vascular device use and outcomes.²² Empowering these clinicians to

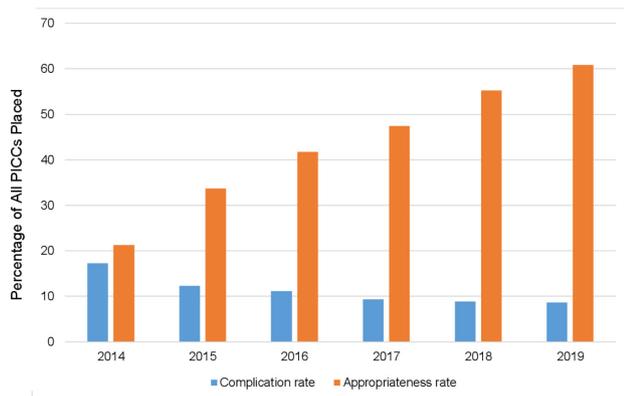


Figure 1 Bar graph showing changes in catheter appropriateness and PICC-related complications during implementation of MAGIC in 42 Michigan hospitals from 2014 to 2019. Complication rate=composite of deep vein thrombosis, central line-associated bloodstream infection and catheter occlusion. Appropriateness rate=percentage of all placements that met MAGIC criteria for appropriate use (defined as PICCs placed ≤ 5 days, single lumen device use and avoidance of PICC use in patients with chronic kidney disease (eGFR 45 mL/min or less)). eGFR, estimated glomerular filtration rate; MAGIC, Michigan Appropriateness Guide for Intravenous Catheters; PICC, peripherally inserted central catheter.

serve as ‘consultants’ for vascular access, rather than ‘PICC teams’, is associated with greater evidence-based practice and better outcomes and represents another strategy to improve appropriateness.^{23 24} Finally, to make the business case for appropriateness, showing that MAGIC can improve patient outcomes is key. In an upcoming presentation, we will share data showing how deployment of MAGIC across Michigan hospitals over 4 years led to more appropriate PICC use and to a reduction in lethal complications, including deep vein thrombosis (DVT), catheter occlusion and bloodstream infection (figure 1).²⁵ Considering an attributable costs of DVT of \$15 973 per episode,²⁵ we estimate we have prevented at least 400 such events in our hospitals and reduced associated healthcare expenses by US\$5 million. In a cost-conscious and patient safety-focused era, it is hard to ignore the value proposition afforded by MAGIC.

What is MAGICal about MAGIC is not that it is some secret strategy, special sauce or radical scientific breakthrough. Rather, it is the fact that it brings available evidence to end users in a pragmatic, easy-to-understand way. In doing so, it has helped form a lattice that links clinical practice to appropriateness to patient outcomes and cost. Verma and colleagues have shown us how to do this using administrative data in a different nation under different contexts. Their contribution will help us start to think about how best we can ‘hardwire’ MAGIC into our decision-making. The time appears right to deploy this tool to inform and improve comprehensive intravenous access. Let us go make some MAGIC for our patients.

Twitter Vineet Chopra @vineet_chopra

Funding This study was funded by the Agency for Healthcare Research and Quality (grant number: 1-R18HS-25891).

Competing interests VC has received funding from the Agency for Healthcare Research and Quality related to the development and implementation of the Michigan Appropriateness Guide for Intravenous Catheters.

Patient consent for publication Not required.

Provenance and peer review Commissioned; internally peer reviewed.

ORCID iD

Vineet Chopra <http://orcid.org/0000-0001-8670-9376>

REFERENCES

- Gibson C, Connolly BL, Moineddin R, *et al.* Peripherally inserted central catheters: use at a tertiary care pediatric center. *J Vasc Interv Radiol* 2013;24:1323–31.
- Tejedor SC, Tong D, Stein J, *et al.* Temporary central venous catheter utilization patterns in a large tertiary care center: tracking the “idle central venous catheter”. *Infect Control Hosp Epidemiol* 2012;33:50–7.
- Alexandrou E, Ray-Barruel G, Carr PJ, *et al.* Use of short peripheral intravenous catheters: characteristics, management, and outcomes worldwide. *J Hosp Med* 2018;13.
- Chopra V, Anand S, Hickner A, *et al.* Risk of venous thromboembolism associated with peripherally inserted central catheters: a systematic review and meta-analysis. *The Lancet* 2013;382:311–25.
- Leung A, Heal C, Perera M, *et al.* A systematic review of patient-related risk factors for catheter-related thrombosis. *J Thromb Thrombolysis* 2015;40:363–73.
- Taxbro K, Hammarskjöld F, Thelin B, *et al.* Clinical impact of peripherally inserted central catheters vs implanted Port catheters in patients with cancer: an open-label, randomised, two-centre trial. *Br J Anaesth* 2019;122:734–41.
- Clatot F, Fontanilles M, Lefebvre L, *et al.* Randomised phase II trial evaluating the safety of peripherally inserted catheters versus implanted Port catheters during adjuvant chemotherapy in patients with early breast cancer. *Eur J Cancer* 2020;126:116–24.
- El Ters M, Schears GJ, Taler SJ, *et al.* Association between prior peripherally inserted central catheters and lack of functioning arteriovenous fistulas: a case-control study in hemodialysis patients. *Am J Kidney Dis* 2012;60:601–8.
- McGill RL, Tsukahara T, Bhardwaj R, *et al.* Inpatient venous access practices: PICC culture and the kidney patient. *J Vasc Access* 2015;16:206–10.
- Chopra V, Flanders SA, Saint S, *et al.* The Michigan appropriateness guide for intravenous catheters (magic): results from a Multispecialty panel using the RAND/UCLA appropriateness method. *Ann Intern Med* 2015;163:S1–40.
- Moureau N, Chopra V, peripheral I for. Midline and central catheters: summary of the magic recommendations. *Br J Nurs* 2016;25:S15–24.
- Woller SC, Stevens SM, Evans RS. The Michigan appropriateness guide for intravenous catheters (magic) initiative: a summary and review of peripherally inserted central catheter and venous catheter appropriate use. *J Hosp Med* 2016;11:306–10.
- O’Grady NR. Demystifying vascular access in hospitalized patients. magic makes a difference. *Ann Am Thorac Soc* 2015;12:1434–5.
- The MAGIC App. Available: <https://www.improvepicc.com/magic-app.html>

- 15 Swaminathan L, Flanders S, Rogers M, *et al.* Improving PICC use and outcomes in hospitalised patients: an interrupted time series study using magic criteria. *BMJ Qual Saf* 2018;27:271–8.
- 16 Rogers M, Flanders SA EMM, *et al.* Applying magic to Improve PICC appropriateness in 42 Michigan hospitals. *J Hosp Med* 2019.
- 17 Chopra V, Smith S, Swaminathan L, *et al.* Variations in peripherally inserted central catheter use and outcomes in Michigan hospitals. *JAMA Intern Med* 2016;176:548–51.
- 18 Verma AA, Kumachev A, Shah S, *et al.* Appropriateness of peripherally inserted central catheter use among general medical inpatients: an observational study using routinely collected data. *BMJ Qual Saf* 2020;29:905–11.
- 19 Paje D, Flanders SA, Bernstein SJ, *et al.* Peripherally inserted central catheters in patients with advanced chronic kidney disease. *Ann Intern Med* 2019;171:683–4.
- 20 Yokoe DS, Anderson DJ, Berenholtz SM, *et al.* A compendium of strategies to prevent healthcare-associated infections in acute care hospitals: 2014 updates. *Infect Control Hosp Epidemiol* 2014;35:S21–31.
- 22 Chopra V, Kuhn L, Ratz D, *et al.* Vascular nursing experience, practice knowledge, and beliefs: results from the Michigan PICC1 survey. *J Hosp Med* 2016;11:269–75.
- 22 Krein SL, Kuhn L, Ratz D, *et al.* The relationship between perceived role and appropriate use of peripherally inserted central catheters: a survey of vascular access nurses in the United States. *Int J Nurs Stud* 2017;71:28–33.
- 23 Krein SL, Kuhn L, Ratz D, *et al.* Use of designated nurse PICC teams and CLABSI prevention practices among U.S. hospitals. *J Patient Saf* 2019;15:293–5.
- 24 Chopra V M, OM JH. Making MAGIC in Michigan. In: *Society of hospital medicine annual national meeting research plenary presentation*. San Diego, CA, 2020.
- 25 Evans RS, Sharp JH, Linford LH, *et al.* Reduction of peripherally inserted central catheter-associated DVT. *Chest* 2013;143:627–33.