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Safe and reliable venous access is the foundation for medication administration in critical and intensive care unit (ICU) patients. Several important issues surround vascular access in the ICU setting, including the need for multiple multi-lumen devices for delivery of concomitant drugs and the frequent sampling of blood from catheters. Risk factors associated with catheter-related complications in ICU patients are coma/immobility and the number of catheters present (Villamarín-Bello et al. 2016). The risk of complications associated with central venous catheters is higher in ICUs compared to other departments, with 35% greater prevalence in one prospective study evaluating peripherally inserted central catheters (Leroyer et al. 2013). Balancing the clinical needs of clinically unstable patients with risks associated with numerous vascular devices requires a process for device selection, aseptic insertion, management and removal of devices when no longer necessary.

Central venous access devices commonly used in ICUs pose significant infectious and thrombotic risk to patients (Maki et al. 2006). Potential risk factors identified as contributing to the development of infectious and thrombotic complications are the patient's underlying disease, type of catheter, immobility, sedation

MAKING THE MAGIC

Guiding Vascular Access Selection for Intensive Care - a Summary of Michigan Appropriateness Guide for Intravenous Catheters (MAGIC)

Determining appropriateness for vascular access devices limits the risk of complications in critically ill patients. Michigan Appropriateness Guide to Intravenous Catheters (MAGIC) establishes evidence-based indications as summarised in this paper.

and duration of catheter use (Richet et al. 1990). The concern for thrombosis includes lower extremities for immobile patients, but also heightened concern for upper extremity thrombosis from central venous access devices (CVAD) (Kearon et al. 2012; Clemence and Maneval 2014). Central devices inserted in the arm, such as peripherally inserted central catheters (PICCs), have a higher risk of thrombosis, with incidence in the literature ranging from 2-75% (Chopra et al. 2013; Clemence and Maneval 2014; Fallouh et al. 2015). Increasing use of PICCs in intensive care has similarly led to greater levels of thrombosis in this patient population (Chopra et al. 2013a). The association between thrombosis, infections and central catheters highlights why use of devices such as PICCs should be considered only when indicated (Evans et al. 2010; Chopra et al. 2012; Chopra, Anand et al. 2013; Chopra et al. 2013b; Malinoski et al. 2013; Moureau 2013; Marschall et al. 2014).

Guidance for selection with evidence-based indications for PICCs or other chest-inserted central catheters (CICC) has been lacking despite recommendations for hospitals to establish tighter criteria. The Society of Healthcare Epidemiology of America (SHEA) recommends providing clinicians with easy access to an evidence-based list of indications for CVC, prior to placement, to minimise unnecessary central catheters and limit risk of central line-associated bloodstream infections (CLABSI) (Marschall et al. 2014). In an effort to address the issues and potentially reduce vascular access device risk to patients, a multi-disciplinary panel of national and international experts was convened to examine criteria for appropriate placement of peripherally inserted central catheters (PICCs) in comparison with other peripheral and central venous devices

(Chopra et al. 2015). The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): Results from a Multispecialty Panel Using the RAND/UCLA Appropriateness Method reflects the in-depth evaluation of vascular access devices to provide the evidence needed to guide selection (Chopra, Flanders et al. 2015).

Methods

MAGIC was formulated using the RAND Corporation/University of California Los Angeles (RAND/UCLA) Appropriateness Method (Fitch et al. 2001). Following systematic reviews of the literature and compilation of available evidence, clinical scenarios were created to rate the appropriateness of insertion, maintenance and care of PICCs in comparison with other peripheral and central venous access devices. Using a conceptual framework of categories such as duration of use, type of infusate, patient, device and provider factors, scenarios were developed for ratings. In accordance with the RAND/UCLA method, the purpose of the panel was not to reach consensus, but rather evaluate why disagreement occurred in order to minimise misunderstandings when rating each scenario. A multi-specialty group of experts was selected to review the literature and rate the appropriateness of each of the scenarios for each of the devices including peripherally inserted central catheters (PICCs), ultrasonography-guided peripheral intravenous catheters, midline catheters, and peripheral intravenous catheters, non-tunnelled CVCs, tunnelled CVCs and ports.

Results of MAGIC

A summary of appropriate and inappropriate vascular access applications follows and is condensed in **Table 1 Vascular Access Dashboard**. For more detailed information on the

Table 1. Vascular Access Dashboard

Device	PIV	USGPIV	MIDLINE	PICC	CVC non-tunnelled	Antimicrobial CVC	Tunnelled CVC	PORT
Indicators	Immediate intravenous access, general infusions. Treatment with peripherally compatible infusion. Forearm placement more reliable	Difficult access patient (DIVA) with 1 or more attempts Treatment 5 days or less than 14 days (transition to midline). Requires longer peripheral catheter	Difficult access patient (DIVA) less than 14 days. More reliable than USGPIV and may be more appropriate in ICU setting	Central catheter indications for peripherally incompatible infusions/irritants, vesicants, vasoactive medications. Measure vein size to approximate catheter to vein ratio of less than 45%.	Central catheter indications. Critically ill patients requiring vasopressors, haemodynamic monitoring. Subclavian preferred for lower infection risk.	Antimicrobial catheters reduce incidence of infections and may be most appropriate for ICU patients. Central catheter indications. For high risk patients or those with history of infections.	Central catheter indications. Longer term treatment for Parenteral nutrition, cancer, other	Central catheter indications. Longer term treatment for Parenteral nutrition, cancer, other
Treatment	Peripherally compatible infusions	Peripherally compatible infusions	Peripherally compatible infusions	Peripherally incompatible infusions or based on duration	Peripherally incompatible infusions or based on duration	Peripherally incompatible infusions with history of infection	Peripherally incompatible infusions and based on duration	Peripherally incompatible infusions and based on duration
Duration	Treatment 5 days or less. Clinically indicated removal policy may extend time if required and without complications for less than 6 days	Treatment less than 6 days or up to 14 days. Clinically indicated removal policy may extend time if required and without complications	Treatment exceeding 6 days and less than 14 days. Clinically indicated removal policy may extend time if required and without complications	Treatment with any infusion greater or equal to 15 days up to 30 days. Difficult access patient greater than 6 days. Preference for midline with less than 15 days. Any duration for peripherally incompatible infusions.	Treatment 6-14 days. Any duration for peripherally incompatible infusions. Preferred device for critically ill/unstable patients or if haemodynamic monitoring is needed.	Treatment up to 30 days. May be appropriate for catheter exchanges. Applies to PICC and chest inserted CVC (CICC)	Treatment 15-30 days or longer	Treatment 15-30 days or longer
Contra-indications	Circulatory impairment, or hemiparesis. For chronic renal failure (CKD) patients insertion focused on dorsum of the hand.	Circulatory impairment, or hemiparesis. For chronic renal failure (CKD) patients insertion focused on dorsum of the hand.	Circulatory impairment, or hemiparesis, history of upper extremity deep vein thrombosis. No appropriate for CKD patients	Greater risk of thrombosis with unstable, hypercoagulable or patients with history of thrombosis.	Coagulopathies and other patient specific contraindications.	Sensitivity to chlorhexidine or other impregnations.	Without availability of trained inserter	Morbid obesity, coagulopathies
RISK LEVEL	0.2-0.5/1000 catheter days	0.2-0.5/1000 catheter days	0.2-0.8/1000 catheter days	2.1/1000 catheter days Higher risk in Intensive Care areas	2-5/1000 catheter days	1.2-1.6/1000 catheter days	1.6/1000 catheter days	0-0.4/1000 catheter days

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results of MAGIC refer to the complete publication (Chopra et al. 2015).

Peripherally Inserted Central Catheters (PICCs)

Peripherally inserted central catheters (PICCs) are currently used in all care settings with a

reported volume of 2.9 million per year used in the USA market alone (iData Research 2014). Specific indications for PICCs in intensive care areas include administration of vasopressors, delivery of peripherally incompatible infusions, parenteral nutrition, frequent blood sampling of three times a day or more,

need for invasive haemodynamic monitoring, or patients who may require infusions greater than 15 days (**Table 1 Vascular Access Dashboard**). Importantly several studies (including a recent randomised trial and a meta-analysis of 64 studies) suggest that the risk of upper-extremity thrombosis is higher for PICCs in

critically ill patients (Chopra et al. 2013). For this reason, non-tunnelled CVCs are rated as appropriate for use in ICU settings over PICCs when such use is proposed to last <14 days. In patients with chronic kidney disease (CKD) (glomerular filtration rate of less than 45 mL/min, creatinine level greater than 3.0, those on dialysis or with stage 3b CKD or greater) peripheral access with PICCs is considered inappropriate and should be preceded by nephrology consultation (Hoggard et al. 2008; Drew and Weiner 2016). In patients with difficult access and no central infusion indications, MAGIC recommendations list a preference for ultrasound-guided peripheral catheters or midline devices rather than PICCs.

Short Peripheral, Ultrasound-Guided Peripheral and Midline Catheters

Indications for short peripheral catheters include immediate intravenous access for peripherally compatible infusions with treatment duration of 5 days or less. Short peripheral catheters are available in 1-6cm lengths with the longer 4-6cm catheters used with ultrasound-guided deeper catheter insertions. Specialists are often called upon when peripheral catheters fail or when multiple peripheral cannulation attempts are required (Helm et al. 2015). Ultrasound-guided peripheral catheters (USGPV) are indicated for patients with difficult intravenous access (DIVA), defined as patients having one or more failed cannulation attempts. USGPV or midlines are beneficial when central access devices are no longer necessary or indicated. Reports demonstrate 92-99% success with USGPV cannulation when education, supervised insertions and competency assessment are established for inserters (Chinnock et al. 2007; Mills et al. 2007; Bauman et al. 2009; Gregg et al. 2010; White et al. 2010; Witting et al. 2010; Moureau 2013; Deutsch et al. 2014). In one study of 148 USGPV insertions, 40 CVADs were discontinued and 34 CVADs avoided with placement of peripheral catheters using ultrasound guidance (Gregg et al. 2010).

While ultrasound can be used to place any intravenous catheter, we use the term USGPV to refer to the ultrasound needle-guided placement of catheters of greater length (4-6cm), owing to the greater depth needed for access (Keyes et al. 1999). USGPV are appropriate for difficult access patients requiring treatment for 6 or fewer days or up to 14 days with peripherally compatible infusions. Midline catheters

provide even greater catheter length for longer dwell. Midline catheters range from 8-20cm in length with the terminal tip in the basilic, brachial or cephalic veins. Notably midlines should not extend into the axillary vein or enter the chest (Gorski et al. 2016). Indications for midline catheters mirror USGPV for indications of treatment up to 14 days. Additionally midlines may be a more reliable peripheral catheter for intensive care patients, owing to their longer dwell time and more stable upper arm placement (Anderson 2004; Mills et al. 2007; Garcia 2009; Alexandrou

the risk of upper-extremity thrombosis is higher for PICCs in critically ill patients

et al. 2011; Morrison 2012; Warrington et al. 2012; Baliad and Peterson 2013; Dawson and Moureau 2013). A policy ensuring that peripheral catheters are removed when clinically indicated rather than on a routine basis is also recommended by MAGIC. (Rickard et al. 2012; Webster et al. 2013; Tuffaha et al. 2014).

Chest Inserted Central Catheters (CICC)

MAGIC examined the appropriateness of non-tunnelled chest inserted central catheters, tunnelled catheters, as well as subcutaneously implanted ports in comparison with PICCs. Based on treatment, the peripheral compatibility of the infusate, proposed duration of infusion and other factors dictating the need for central administration, the use of non-tunnelled acute care catheters for 6-14 days was considered appropriate. Non-tunnelled catheters are preferred over PICCs when risk factors for thrombosis are present or when there is a history of deep vein thrombosis (Chakravarthy et al. 2005; Evans et al. 2010; Chopra et al. 2013). Preference was given for non-tunnelled CVADs for patients who were haemodynamically unstable, actively receiving vasopressors or requiring urgent central venous access (Chopra et al. 2015). Tunnelled catheters were indicated when at least 3 months of treatment were needed. Ports were considered appropriate for treatment that required intrave-

nous access for 6 months or more and neutral for treatment of 3-6 months.

Conclusion

Maintaining vascular access is a top priority in the intensive care patient population. The selection of vascular access devices for critically ill patients requires the clinician to consider many factors that impact patient risk and safety. With prolonged immobility and critical illness, the risk of thrombosis and infection must be factored into the equation when selecting a device. Selection criteria established within the MAGIC guide can help determine which device is associated with least risk and meets treatment needs of the patient (Anderson and Spencer 2003; Maki et al. 2006; Crowley et al. 2008; Chopra et al. 2012; Clemence and Maneval 2014; Chopra et al. 2015). MAGIC provides guidance and measurement criteria through which to assess the appropriateness of PICCs and other vascular access devices for the intensive care patient (Chopra et al. 2015; Woller et al. 2015). Application of MAGIC by clinicians and providers within intensive care areas may assist hospitals in establishing reliable access, improving outcomes, achieving infection prevention goals and reducing burden of thrombosis.

Conflict of Interest

Nancy Moureau declares that she has no conflict of interest. Vineet Chopra declares that he has no conflict of interest. ■

Abbreviations

CICC	chest inserted central catheter
CKD	chronic kidney disease
CLABSI	central line-associated bloodstream infections
CVAD	central venous access devices
CVC	central venous catheter
DIVA	difficult intravenous access
ICU	intensive care unit
PICC	peripherally inserted central catheters
MAGIC	Michigan Appropriateness Guide for Intravenous Catheters
USGPV	ultrasound-guided peripheral catheters

For full references, please email editorial@icu.management.org, visit icu-management.org or use the article QR code.