

Matching the peripheral intravenous catheter to the individual patient

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Abstract : Up to eighty percent of all patients admitted to hospital worldwide will receive a peripheral IV and this procedure is now considered indispensable to human health. However, despite its global use, the choice of catheter is not always governed by clear and universal guidelines. After reviewing the few best-practice recommendations which exist, we propose a patient – and therapy – driven matrix for deciding on the gauge and length of peripheral catheter for the individual patient. This matrix takes patient age, clinical stability, current state of veins, therapy duration and the nature of the medication to be delivered into consideration. Use of such a matrix will not deliver a formulaic answer but will orient choices along logical, evidence-based lines. This approach will be an advance on the all-too-common reliance on habit and tradition in the choice of peripheral IV catheter.

Key words : Peripheral venous catheterisation ; equipment, venous access device ; guidelines.

INTRODUCTION

Peripheral intravenous (IV) lines are placed in nearly four out of five hospitalized patients (1). For such a remarkably common procedure one would expect clear guidelines to inform clinical practice, but this is, unfortunately, in many settings, not the case. When confronted with the question, ‘which catheter did you choose and why?’ the majority of answers given by medical practitioners, experienced in placing IVs, reveals confusion and a disturbing reliance on habit and tradition as well as on logistic factors such as availability and procurement habits of their ward or hospital. It is our belief that evidence-based protocols for IV therapy should guide best practice and provide legal and ethical frameworks both for health care professionals and for patients.

In a previous paper (2) we reviewed the history of IV therapy from the Middle Ages to the present. This paper intends to examine the evidence for best practice in regards peripheral IV therapy today.

Based on this evidence we propose a simple, logical and clinically-sound means of choosing the right catheter for the individual patient.

PERIPHERAL CATHETER INSERTION GUIDELINES

The practitioner must start by choosing the appropriate vein for IV therapy, avoiding areas of flexion, the dominant arm (if possible), sites of previous surgery or injury, areas of infection or skin breakdown and, in all cases, the lower extremity (3). The largest peripheral arm veins are usually found in the forearm, but these are sometimes easier to palpate than to see. Hand veins, by contrast, are easier to see but can be smaller, more torturous and fragile. Applying the tourniquet can help identify target veins, but it must be taken off afterwards, while preparing the procedure. The inserter must wash hands, prepare equipment on a sterile field and check expiry dates. Encourage venous filling by applying warmth or using gravity (not by tapping as this can lead to reflex constriction of veins) and cleanse the site according to local policy guidelines. Do not repalpate area after cleansing. Reapply a tourniquet, apply gloves and adopt favoured grip to hold the cannula. Ensure the bevel of the cannula is in the upward position as this facilitates

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vein puncture and reduces trauma to the skin and vein on puncture (4). Apply skin traction using the thumb of one's non-dominant hand and, with the fingers of that hand, hold the hand or arm to be cannulated. Skin traction keeps the skin taut aiding visibility and prevents the vein rolling away at the moment of entry with the cannula (4). Insert the cannula through the skin and subcutaneous tissue either just above or adjacent to the vein at an angle of 10-45 degrees according to the depth of the vein. The deeper the vein the greater the angle required. Advance until blood is seen in the flashback chamber of the cannula confirming entry into the vein. Immediately decrease the angle of the cannula to nearly parallel to the skin and advance a further 2 mm into the vein. This 2 mm is approximately the length of the trim distance and ensures that both stylet and cannula have entered the vein. Advance the cannula fully into the vein using one of two methods: 1) Withdraw the stylet slightly so that it is within the cannula but still in the vein and advance the whole unit. This method is sometimes referred to as the 'hooded' technique; 2) Hold the stylet still and slide the cannula over it until the latter is threaded to its hub. This method is called the 'over the needle' technique. Never reinsert the stylet into cannula. This may cause part of the cannula to break off and enter the circulatory system. Secondary flashback of blood within the intravascular part of the cannula (in the gap between the steel and the plastic) during advancement confirms placement in the vein. The user should then release the tourniquet and applying digital pressure beyond the tip of the cannula to prevent blood spillage. This tip will not be visible and the distance must be estimated based on the remembered length of the catheter. The stylet should be immediately disposed of directly into a sharps box to reduce the risk of needle stick injury. All intravenous attachments must then be secured via screw-on Leur Lok connections to reduce the potential risk of disconnection. Then apply a secure, transparent, semi-permeable dressing and flush the catheter according to local policy. Flushing is usually done with 2-5 mls of normal saline using positive pressure. This is achieved by maintaining continual pressure on the syringe plunger while withdrawing the needle or needle-free adapter, thus preventing backflow of blood into the cannula. After insertion, the catheter should be inspected at least once a day and preferably every shift for the duration of its dwell time. Guidelines suggest that peripheral IVs be changed every 72-96 hours (5, 6), but the presence of more than 4 mm of redness, tenderness or warmth to

palpation and/or streaks or cords upstream from the insertion site should lead to immediate removal of the catheter and, in the case of pus or frank infection, culturing of its tip. Documentation is essential and must include who inserted, dressed and flushed the cannula; the date and time the cannula was inserted; type of cannula, gauge site used and reason for cannulation. Cannulation must only be attempted twice. If both attempts fail the practitioner must refer to a more experienced colleague.

CURRENT STATE OF GUIDELINES

When one searches for specific recommendations as to which catheter to use for an individual patient, there is remarkably little practical guidance. Studies which surveyed nurses in a formal manner (6-8) as to the reasons for their choice of one catheter over another report the following as common reasons: *tradition* (i.e. 'I've always used that kind.');

patient type (i.e. 'I give older, obese patients smaller catheters than young, slim ones, who get the large ones');

size and site of vein (i.e. 'I put smaller catheters in hand veins, larger ones in forearm veins');

peer opinion (i.e. 'When in doubt, I ask a more experienced person');

therapy anticipated (i.e. 'I place a larger catheter if I think there will be a need for rapid fluid replacement'). While there may be merit in all of these answers, they remain inadequate to guide best practice in this day of evidence-based, resource-constrained medicine.

The confusion that characterizes these issues for users is reflected in patient understanding, or lack thereof, for the procedure. Only a minority of patients with IVs, when asked, can state clearly the reason why they have a catheter and how they are collaborating with their nurse to take care of it. Even fewer know the symptoms to watch out for and report on. When time is taken during the insertion procedure to inform and answer questions, patient cooperation is enhanced and complication risk, reduced.

Leading professional and manufacturing organizations have published recommendations on which catheter to use in different circumstances (Table 1).

Intravenous Nurses Society (INS): In the Policies and Procedures for Infusion Nursing (9) first published in 2000 by the Intravenous Nurses Society (INS) and revised in 2006 (10), the following general guideline is given: 'Select the smallest gauge and shortest length to accommodate the prescribed therapy.' This clearly implies that the first

Table 1

Recommendations by different organizations on the use of specific catheter gauges

Size Gauge	INS Recommendations (9,10)	UK Recommendations (11)	BD Recommendations
12 G 13 G	*	Major resuscitative procedures requiring rapid transfusions ; mainly used in theatres	
14 G		High volume transfusions ; mainly in operative procedures	Used in theatres or emergency for rapid transfusion of blood or viscous fluids
16G	Trauma patients Surgery patients Blood transfusion	High volume transfusions ; mainly in operative procedures	Used in theatres or emergency for rapid transfusion of blood or viscous fluids
17G		IV fluid therapy and blood transfusions	Blood transfusions, rapid infusion of large volumes of viscous liquids
18G	Trauma patients Surgery patients Blood transfusion	IV fluid therapy and blood transfusions	Blood transfusions, parenteral nutrition, stem cell harvesting and cell separation, large volumes of fluids
20G	Continuous infusions Intermittent infusions Blood transfusion	Blood transfusions, medication and IV fluid therapy	Blood transfusions, large volumes of fluids
22G	General infusions Intermittent infusions Blood transfusion Children and elderly	Medication ; Paediatric patients	Blood transfusions, most medications and fluids
24G	Fragile-veined patients Children General infusions Intermittent infusions	Medication ; Paediatric patients	Medications, short term infusions, fragile veins, children
24G(N)			Neonatal

* spaces left blank are not addressed in respective organization's recommendations.

INH = Intravenous Nurses Society ; UK = United Kingdom Expert Panel ; BD = Becton Dickinson.

step a practitioner must take in selecting a catheter is to be completely familiar with the therapeutic road-map planned for the patient, including medications, length of treatment, surgical interventions planned and possible adverse events (e.g. dehydration, cardio-vascular event) which could result. The INS procedures go on to specify the gauge size appropriate for specific therapeutic road-maps (Table 1). Note that blood transfusion can require gauge sizes ranging from 16 to 22, while intermittent infusions range from 20-24 gauge.

Expert Panel (UK) : Recently agreed guidelines in the United Kingdom (11) also suggest choosing the peripheral IV catheter size for adults according to the clinical application relevant to the patient (Table 1).

Leading Manufacturer of Catheters : One leading manufacturer of catheters and needles has also published recommendations (12) (Table 1). Other companies have made similar recommendations.

PATIENT CRITERIA IN THE CHOICE OF CATHETERS

While no absolute gauge (catheter diameter) recommendations can be made across the board, we have developed a matrix involving a number of simple parameters in the individual patient which then points users in a direction along a spectrum from smaller to larger catheter sizes. The best way to use this guidance is to add the parameters (elements under heading) in a formulation such as : 'If ... think (heading title : smaller or larger diameter) :

<i>Smaller diameter (20-24G)</i>	<i>Larger diameter (14-20G)</i>
Paediatric patient	Adult patient
Medical therapy	Surgical therapy
Difficult or small veins	Visible/palpable veins
Cardiovascular stable	Resuscitation anticipated

Using the above parameters, a patient matrix definition can be derived which then informs the choice of catheter gauge.

Matrix definition of patient	Recommended Catheter Gauge (G)
Paediatric medical	26
Paediatric surgical	22 24
Paediatric resuscitation	20 22 or CVP*
Adult medical poor veins	22 24
Adult surgical poor veins	18 20 or CVP
Adult medical good veins	20 22
Adult surgical good veins	16 18
Adult resuscitation	14 16 or CVP

*Central Venous Pressure catheters ('P' is a historic reference to the original use of these catheters for measuring pressures).

Similar considerations apply to the choice of catheter length. Again the best way to use this guidance is to add the parameters in a formulation such as : 'If ... think (shorter or longer length) :

Shorter Length (30-40 mm)	Longer Length (40-50 mm)
Paediatric patient	Adult patient
Hand site	Arm site
Tortuous vessel	Straight vessel
No visible or palpable valves	Visible or palpable valves

As with gauge, using the above parameters, a patient matrix definition can be derived which then informs the choice of catheter length.

Matrix definition of patient	Recommended Catheter Length (mm)
Paediatric hand	30
Paediatric arm	30-40
Adult hand	30-40
Adult arm palpable valves	30-40
Adult arm tortuous vessel	30-40
Adult arm no palpable valves	30-50
Adult arm straight vessel	30-50

Note that a larger range is allowed in length than in gauge. The longer the catheter the more resistance the fluid encounters and the slower the flow. Therefore, when slow drip, medical therapy is anticipated, the longer end of this range may be used ; when rapid infusion, surgical therapy is anticipated, the shorter end of this range is best.

While the use of this matrix approach is, in our opinion, a step forward it remains intentionally and inevitably general. No set of recommendations will ever be able to tell the user the exact gauge size and exact catheter length to be chosen for a specific patient. The importance change is that one no longer picks 'the green catheter' because one has always used the green one and has the most insertion success with it, but rather that one looks carefully at the patient and weighs certain key parameters before taking a decision. Where possible the specific therapy planned for the patient should also be factored into this decision. A number of studies

have been published addressing the optimal catheter as a function of the therapy to be given.

THERAPY CRITERIA IN THE CHOICE OF CATHETERS

Catheter matched to the infused therapy

Parenteral nutrition : Standard-feed parenteral nutrition has an osmolality of 1250 mOsmol/kg. Such loads were traditionally given via central lines (13), but recently there has been mounting evidence regarding the safety of their delivery via the peripheral route (14). Fine-bore (22 or 23G) catheters are ideal for short- to medium-term parenteral nutritional support. But the type of catheter used is critical. Thrombophlebitis develops in almost all peripheral catheters made of Teflon (15) which are used for this application while it is rare with those made of silicone. Furthermore, polyurethane appears to be superior even to silicone in incidence of occlusion and in median survival in situ. In one study (16) the polyurethane catheters survived a median of seven days, versus only three days for silicone. When 5 cm vs 15 cm catheter lengths were compared (7), the incidence of thrombophlebitis or extravasation did not differ, suggesting that there is no influence of the length of catheter within the vein. However catheters inserted into basilic veins had fewer complications than those inserted into cephalic veins. One could conclude that when the patient is likely to receive parenteral nutrition, one should choose a 22 or 23 G polyurethane catheter.

Antibiotics : Administering antibiotics through peripheral catheters increases the risk for infusion phlebitis (8, 17). In one study (18) nearly one out of five patients receiving antibiotics developed phlebitis, while the incidence was less than one out of ten if they were not receiving such drugs. This risk is multifactorial, involving the irritation to the endothelium by substances radically different in pH and osmolarity to blood, the length of time that catheters remain in during antibiotic therapy and the patient population to which antibiotics are given (more likely to be bacteremic). There may also be an increased risk dependant on which antibiotic is given, with dicloxacillin and erythromycin having the highest risk in one study (18). Interestingly the risk with dicloxacillin is greater than with cloxacillin (19). Benzylpenicillin, cefuroxime and cloxacillin carry a moderate risk and ampicillin, imipenem/cilastatin, clindamycin, netilmicin and vancomycin, a low one. The administration of

fructose-glucose and anticoagulants can also increase the risk (8). It has been shown that catheters made of polyurethane permit longer catheterization with less risk for phlebitis, therefore when the administration of antibiotics is anticipated ; such catheters should be used (8).

One could conclude that when the patient is likely to receive antibiotics one should choose a polyurethane catheter.

Chemotherapy or vesicant therapy : Chemotherapies are cytotoxic agents given for malignant and non-malignant (often inflammatory) conditions. Vesicant agents are medications that cause blisters, severe tissue injury or necrosis when they infiltrate out of peripheral catheters into the surrounding soft tissue (20). Vincristine and doxorubicin are two examples of vesicant chemotherapeutic agents given via continuous IV line to appropriate patients. Such agents are usually given by central venous line. Patients with malignant conditions are at high risk for extravasation because of repeated IV access, edema from low protein states and other conditions and their fragile veins. Successful use of peripheral IV routes for giving chemotherapy has been demonstrated. In one study 89% of patients treated in the outpatient setting for a variety of cancers (colo-rectal, lung, leukemia) completed their course of chemotherapy with the originally-placed catheter when they were used for 3-5 days (21). It appeared that the 24 G catheters performed worse than those with larger lumens, possibly because of its short length and narrow tubing. When chemotherapy is given via a peripheral line using a pump injector, the lowest possible pump settings should be used and the infusion site should be checked frequently (22). In that case, one should choose a 22 or 23 G catheter and ensure venous placement by demonstrating free blood reflux.

Transfusions : Guidelines regarding the appropriate catheter to use for blood or platelet transfusions are exceptionally broad. Scanning of the recommendation tables above reveals that blood transfusion can require gauge sizes ranging from 16 to 22. It is generally agreed that the larger catheter sizes allow faster transfusion with less haemolysis or thrombosis risk but carry a higher risk of pain and phlebitis. Thinner gauges have exactly the opposite advantage array and risk profile. More than in any other infusion arena, that of transfusion requires individual assessment of the patient. For example, a stable patient with thrombocytopenia due to chemotherapy and requiring a slow infusion of platelets may do well with a 22 G catheter placed in the dorsum of the hand. However, a patient with

unstable angina and anaemia, at high risk for ventricular fibrillation or other malignant arrhythmia, who needs rapid red cell replacement should have, at minimum, a 16 or 18 G catheter in a large forearm vein.

One could conclude that when the patient is likely to receive a transfusion a great deal of flexibility is allowed and the choice of catheter is dependant on many individual factors.

Resuscitation : Medical crises when large volumes of fluids (usually crystalloids) must be given include hypovolemic shock, cardiogenic shock and cardiopulmonary arrest. The ability to give 1-5 litres of fluid quickly is dependent on having a large bore-catheter in place in a large and open vein. Often, when such volumes are required, physicians will add external pressure to the bag and will not depend entirely on gravity. The volume of fluid that can be given depends on the complex interaction between a rigid (or semi-rigid) catheter and tubing and a compliant vein. Models have shown (23) that high resistance in the venous system (as can occur with collapsed or thrombosed veins, closed valves, oedema, etc.) can prevent increased flow despite increased infusion pressure. This is true for conditions in the central venous system but is also true when one attempts to force fluid through small catheters placed in small veins. In the latter case, increased flow rates can only be achieved by using two independent infusion ports (in practice, placing an additional line). Because of these physiologic findings and the urgency of rapid fluid administration in trauma and other resuscitation settings, the placement of a 14 or 16 G catheter in a large peripheral vein is a minimum requirement. It must, however, be recognized that the effect of venous resistance is greatest on large-bore catheters, with significant reductions to flow seen with only small increases in resistance (24). At the range of resistances we encounter clinically, flow through two low-gauge catheters is greater than that through a single large-gauge one. Therefore to have its desired effect on flow the large-bore catheter must be placed into a large (i.e. low resistance) vein. If a large vein is not found, it is more clinically advantageous for the patient to have two small-bore catheters.

One could conclude that when the patient is likely to need rapid fluid administration for resuscitation, one should ensure the presence of at least one large-bore catheter (14 or 16 G) in a large peripheral vein or two smaller-bore catheters (18 or 20 G) in two separate veins. One must also consider placing a prophylactic central line.

Catheter matched to the interventional therapy

Surgery anticipated: A number of studies have shown that up to half of all catheters inserted in the peri-operative period develop phlebitis. GAUKROGER *et al.* (25) found the overall phlebitis incidence to be 52% in catheters used for anesthetics, i.e. intra-operative and postoperative purposes, while MAKI & RINGER (17) reported a 42% incidence and PANADERO *et al.* (26) a 63% one. Catheters placed for 'medical' reasons only had lower rates of phlebitis, as CAMPBELL (27) found the incidence to be 26%, BREGENZER *et al.* (28) 20% and RYPINS *et al.* (29), 18%. It should be pointed out that larger-bore catheters are usually used in the surgical setting versus the medical. There may be more friction-associated effects from these larger catheters which may predispose to phlebitis. Factors that can increase the risk for phlebitis in the peri-operative setting are hurriedness, lack of skill or roughness in technique (25). Poor anchorage of the catheter after placement and the use of teflon rather than polyurethane are also factors associated with increased thrombophlebitic risk (17). The use of a polyurethane catheter appears to decrease the risk of post-operative phlebitis (25, 30).

One catheter or two for postoperative use? There is an association between postoperative catheter-related thrombophlebitis and the intra-operative use of the same catheter (25, 30). Placing of two catheters, one for intra-operative use and the other for postoperative use, reduces significantly the incidence and severity of postoperative, peripheral, catheter-related phlebitis (26). One could conclude that when the patient is likely to receive surgical intervention one should use a large-bore (14, 16 or 18G) polyurethane catheter and consider placing two catheters, one for intra-operative use and the other for postoperative use. For unstable patients one must consider placing a central line.

Cardiovascular intervention: Patients admitted with unstable angina or myocardial infarction will often need IV drugs, fluids and transfusions. Such patients will often proceed to interventional procedures such as angioplasty (PTCA) with or without splint or by-pass surgery (CABG). They will require at least one peripheral IV line with a large enough bore to ensure adequate flow in the case resuscitation is required. Additionally a central venous line may be placed. It would usually not be adequate to place only a 24 G catheter in the back of the hand. Such patients, especially if male, should have larger catheters (e.g. 18 or 20 G) placed in a large forearm vein.

One exception to this rule involves the use of vasopressors. One should be especially careful when using dopamine through a peripheral line. In one study (31) the infiltration rate when using this agent was 68%. This complication is associated with necrosis, skin sloughing, discoloration and gangrene. The same complications are seen with other vasopressors such as neosynephrine, epinephrine and norepinephrine. Central venous lines should be used when giving these agents. However, in the situation where a peripheral line must be used, the recommendations of the Intravenous Nurses Society (9, 10, 31) are to use the smallest gauge catheter possible, avoid the hands and antecubital fossa and monitor the site hourly to assess for infiltration. One could conclude that when the patient is likely to receive cardiovascular intervention, one should use a medium to large-bore (16, 18, 20 G) polyurethane catheter or a central line.

'Chemically-challenging' medications: Vasopressors and/or catecholamines, pH, osmolarity: Skin necrosis can occur after extravasation of low-dose vasopressin given via peripheral IV for conditions such as vasodilatory septic shock (32). When such therapies involving catecholamines are anticipated, it may be recommended to use longer catheters when the choice is available. Many medications lie at the extremes of physiologic normality. It is beyond the scope of this paper to provide a full list of medications that challenge the vascular system by their extremes of pH and osmolarity and which carry an increased risk of local damage if extravasated or of chemical phlebitis even when the infusate remain IV. Such lists are provided in a number of texts and articles (22). One could conclude that when the patient is likely to receive vasopressor therapy or chemically-challenging medications, one should use longer catheters and ensure venous placement by demonstrating free blood reflux.

DISCUSSION

Today, up to 80% of all patients admitted to hospital worldwide will receive an IV (1) and this procedure is now considered indispensable to human health. However, despite the global use of IVs and their criticality to health, the procedure is not appropriately trained for, nor is it governed by clear and universal guidelines.

In this paper we reviewed the best practice for insertion technique as well as the published recommendations which attempt to guide the choice of

catheter. We conclude that these recommendations are too general to be of much practical use to the individual patient. If proof is required, surveys of users indicate that such choices are currently guided by habit, peer-advice and 'eye-balling' the patient. In our view, the best use of the findings of the studies reviewed in this paper is via a 'matrix approach'. In this approach specific characteristics of the patient (e.g. age, condition of veins, degree of cardiovascular stability) and the anticipated therapy (e.g. medical vs. surgical) are used as the determining factors which steer the user towards a larger or smaller gauge catheter with a longer or shorter length. Such an approach is implicit in many studies and is workable in our own practice, but its efficacy in larger population-based studies remains to be proven.

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