Frequent malpositions of peripherally inserted central venous catheters in patients undergoing head and neck surgery

Mauvais positionnements fréquents des cathéters veineux centraux insérés par voie périphérique chez les patients subissant une chirurgie au niveau de la tête et du cou

Leonid Minkovich, MD, PhD · George Djaiani, MD ·
Stuart A. McCluskey, MD, PhD · Nicholas Mitsakakis, MSc ·
Ralph W. Gilbert, MB · W. Scott Beattie, MD, PhD

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Abstract

Purpose *Peripherally inserted central venous catheters (PICCs) do not interfere with surgical access during neck dissection and are used in patients undergoing head and neck surgery. However, severe complications associated with malpositioning of PICCs have been reported in these patients. We conducted a retrospective study to determine the incidence of aberrant positioning of PICCs in patients undergoing free flap reconstructive (FFR) surgery for head and neck malignancies.*

Methods *We analyzed a database of 269 patients undergoing FFR surgery. After induction of general anesthesia, a PICC was inserted successfully in 130 patients (48%) at bedside without image guidance. A PICC was not used in 139 patients (52%). A chest x-ray was performed at admission to the postanesthetic care unit, stored digitally, and reviewed retrospectively by two independent observers. Based on the chest x-ray findings, the PICC position was classified as proper, suboptimal, or aberrant and defined according to the position of the PICC tip, i.e., proper, if situated in the ipsilateral innominate*

vein or in the superior vena cava; suboptimal, if situated in the subclavian vein; and aberrant, if situated in any other location.

Results *Proper, suboptimal, and aberrant PICC positions were found in 68 (52%), 17 (13%), and 45 (35%) patients, respectively. The proper position was confirmed more frequently with a left- than with a right-sided approach: 23/29 (79%) vs 45/101 (44%) patients, respectively ($P < 0.001$).*

Conclusions *There is a high incidence of aberrant positioning when PICCs are inserted without image guidance. The left-sided approach might be preferable due to a lower incidence of malpositions. The risk-benefit ratio should be estimated carefully before using a PICC in patients undergoing FFR procedures.*

Résumé

Objectif *Les cathéters veineux centraux insérés par voie périphérique (PICC) n'interfèrent pas avec l'accès chirurgical pendant la dissection du cou et sont utilisés chez les patients subissant des chirurgies au niveau de la tête et du cou. Toutefois, de graves complications associées au mauvais positionnement des PICC ont été rapportées chez ces patients. Nous avons réalisé une étude rétrospective afin de déterminer l'incidence de positionnement aberrant des PICC chez les patients subissant une chirurgie de reconstruction par lambeau libre (RLL) pour des tumeurs malignes à la tête et au cou.*

Méthode *Nous avons analysé une base de données de 269 patients subissant une chirurgie par RLL. Après l'induction de l'anesthésie générale, un PICC a été inséré avec succès chez 130 patients (48 %) au chevet sans échoguidage. Un PICC n'a pas été utilisé chez 139 patients*

L. Minkovich, MD, PhD (✉) · G. Djaiani, MD ·
S. A. McCluskey, MD, PhD · N. Mitsakakis, MSc ·
W. S. Beattie, MD, PhD

Department of Anesthesiology and Pain Management, Toronto
General Hospital, University Health Network, University
of Toronto, 3 Eaton North Wing-410, 200 Elizabeth Street,
Toronto, ON M5G 2C4, Canada
e-mail: leonid.minkovich@uhn.on.ca

R. W. Gilbert, MB
Department of Otolaryngology, Head and Neck Surgery,
Toronto General Hospital, University Health Network,
University of Toronto, Toronto, ON, Canada

(52 %). Une radiographie des poumons a été réalisée lors de l'admission en salle de réveil, enregistrée sous forme numérique et passée en revue rétrospectivement par deux observateurs indépendants. Selon les résultats de la radiographie pulmonaire, le positionnement du PICC était classé comme étant correct, sous-optimal ou aberrant, et défini selon l'emplacement du bout du PICC, c'est-à-dire correct si situé dans la veine innominée ipsilatérale ou dans la veine cave supérieure; sous-optimal si situé dans la veine sous-clavière; et aberrant si situé à tout autre emplacement.

Résultats Des positionnements corrects, sous-optimaux et aberrants du PICC ont été observés chez 68 (52 %), 17 (13 %), et 45 (35 %) patients, respectivement. Un positionnement correct a été confirmé plus fréquemment lors d'une approche par la gauche que par la droite : 23/29 (79 %) vs 45/101 (44 %) patients, respectivement ($P < 0,001$).

Conclusion Il existe une incidence élevée de positionnement aberrant lorsque les PICC sont insérés sans échoguidage. L'approche par la gauche pourrait être préférable en raison d'une incidence moindre de mauvais positionnements. Il convient de bien évaluer les risques et les avantages avant d'avoir recours à un PICC chez les patients subissant des interventions de RLL.

Viability of the free tissue flap depends on adequate perfusion of the vascular pedicle after performing microsurgical free flap reconstruction (FFR) in head and neck surgery.¹ Despite well-known limitations,² central venous pressure (CVP) measurement is still used in many institutions to monitor perioperative fluid therapy. In reconstructive surgery for head and neck malignancies, peripherally inserted central venous catheters (PICCs) are preferred to central venous (subclavian or internal jugular vein) catheters because PICCs do not interfere with surgical access (i.e., neck dissection). We conducted this study to determine the incidence of aberrant positioning of PICCs in this patient population. This information might be clinically relevant because severe complications associated with malpositioning of PICCs have been reported in patients undergoing head and neck surgery.^{3–6}

We sought to determine the incidence of aberrant positioning of PICCs inserted at bedside without image guidance in patients undergoing a FFR procedure.

Methods

Following Institutional Ethics Review Board approval, we performed a retrospective review of the database of

269 adult patients who underwent extensive excision of head and neck malignant tumours followed by microsurgical FFR from 2004 to 2009 at the Toronto General Hospital. A comprehensive quality control database was created pertaining to demographic, laboratory, surgical, and anesthetic variables; amount and composition of intraoperatively administered fluids; co-morbidities; and postoperative complications.⁷ Preoperative co-morbidities were assessed by the American Society of Anesthesiologists (ASA) physical status classification.

The anesthesiologist in charge of the case determined if the patient required CVP monitoring and selected the antecubital vein (basilic or cephalic vein) and the side (right or left) for PICC insertion. Only the antecubital vein was used for PICC insertion. According to institutional protocol we avoided PICC placement on the side of planned neck dissection. If bilateral neck dissection was required, the attending anesthesiologist chose a side for PICC insertion. In cases of radial (forearm) osteocutaneous free flap harvesting, the PICC was inserted into the antecubital vein of the contralateral arm. Radial osteocutaneous free flap was taken from the non-dominant hand.

A PICC insertion was performed in the operating room after induction of general anesthesia with the patient's head placed in the neutral position and the patient's arm abducted at 90°. The PICC was inserted percutaneously through the basilic or cephalic antecubital vein using the Seldinger technique. The radio-opaque double-lumen PICC (CS-17752 7 Fr, Two-Lumen Peripherally Inserted Central Catheter Kit with Blue FlexTip® Catheter, Arrow International Inc., Reading, PA, USA) was used in all patients. The appropriate length of the catheter to be inserted was estimated by measuring a distance along the imagined course of the vein between the point of insertion and the second right intercostal space. The electrocardiogram was monitored continuously during advancement of the guide-wire and PICC to detect arrhythmias. Free backflow of blood from both lumens and observation of a typical CVP trace were mandatory conditions to consider an acceptable PICC position. The catheter was secured over the patient's forearm with an adhesive sterile dressing.

According to protocol, a bedside chest *x-ray* was obtained in all patients at admission to the postanesthesia care unit (PACU) to confirm the location of the PICC. If required, appropriate repositioning of the PICC was done based on results of the chest *x-ray*.

The chest *x-ray* films were stored digitally and reviewed retrospectively by two independent observers (L.M. and G.D.) to determine the incidence of aberrant positioning of PICCs. The PICC tip was considered in the proper position if it resided anywhere between the origin of the innominate (brachiocephalic) vein and the junction between the superior vena cava and the right atrium. Location of the PICC

tip within the ipsilateral subclavian vein was considered as suboptimal. All other locations were considered as aberrant. Thoracic venous anatomy was defined according to the standard landmarks.^{8,9} The primary outcome of the study was the incidence of proper, suboptimal, and aberrant positions of the PICCs.

Statistics

Data are presented as mean (standard deviation), median [interquartile range], or a number (percentage) for categorical variables. Normal distribution of data was tested with Kolmogorov-Smirnov's test. A non-parametric Wilcoxon two-sample test was applied for continuous variables, and a Fisher's exact test was used for categorical variables.

Results

Table 1 reflects patients' demographic data and ASA classifications. Insertion of a PICC was attempted in 135 (50%) of the 269 patients studied. Failure to cannulate the antecubital veins was reported in two patients, and failure to advance a guidewire was reported in three patients. Successful placement occurred in 130 patients. The antecubital veins of the right and left arms were used in 101 (78%) and 29 (22%) patients, respectively. The basilic vein was used in 68 (52%) patients, and the cephalic vein was used in 62 (48%) patients. There were no reported complications related to PICC insertion.

Good quality chest *x-rays* were obtained in all patients at PACU admission. The inter-observer agreement rate was

91% with respect to interpretation of the PICC positions. Proper, suboptimal, and aberrant positions of the PICC lines were confirmed in 68 (52%), 17 (13%), and 45 (35%) patients, respectively (Table 2). The aberrant positions included the right atrium in 15 patients, the axillary vein in 14 patients, an upward course into the ipsilateral internal jugular vein in 13 patients, retrograde passage through the cephalic vein backward into the axillary vein in two patients, and the contralateral subclavian vein in one patient.

Proper positioning of the PICC was found in 23/29 (79%) patients with left antecubital venous access and in only 45/101 (44%) patients with the right-side approach ($P < 0.001$). The incidence of proper PICC positioning was similar with the basilic 32 (47%) and cephalic 36 (58%) venous accesses ($P = 0.65$).

All catheters were removed within the first 48 hr after surgery. There were no complications associated with PICC removal.

Patients in the PICC group were five years older on average, and they were more likely to have a higher ASA classification (Table 1). The amount of intraoperative fluid administration, duration of surgery, and hospital length of stay were similar in patients with and without CVP monitoring.

Discussion

The main finding of our study was the high (35%) incidence of aberrant positioning when PICCs were inserted at the bedside without image guidance. In addition, suboptimal PICC placement was recorded in 13% of patients. Our

Table 1 Demographic data in patients with and without PICC placement

Variable	PICC (<i>n</i> = 130)	No PICC (<i>n</i> = 134)	<i>P</i> value
Female	50 (38.4%)	57 (42.5%)	0.51
Age (yr)	61.5 (13.8)	56.9 (13.9)	0.0042
Weight (kg)	66.9 (18.1)	69.9 (19.3)	0.17
Height (cm)	168.1 (10)	168.0 (10.2)	0.94
ASA physical status			0.0071
ASA I	4 (3.1%)	5 (3.6%)	
ASA II	32 (24.6%)	55 (41.1%)	
ASA III	84 (64.6%)	56 (42.3%)	
ASA IV	10 (7.7%)	18 (12.5%)	
Duration of surgery (Hours/min)	10:33 (6:12)	10:03 (5:29)	0.83
Total amount of intravenous fluids administered during surgery (mL·kg ⁻¹ ·hr ⁻¹)	8.89 (3.56)	9.45 (3.07)	0.19
Hospital stay (days)	18 [14-25]	16 [13-22]	0.26

PICC = peripherally inserted central catheter; ASA = American Society of Anesthesiologists physical status classification. Data are presented as mean (standard deviation) if normally distributed, median [interquartile range] when normal distribution could not be proved, and as number (percentage) for categorical variables

Table 2 Position of the PICC in patients undergoing a free flap reconstruction procedure for head and neck cancers

Venous access	Proper position	Suboptimal	Aberrant
Right (<i>n</i> = 101)	*45 (44%)	15 (15%)	41 (41%)
Left (<i>n</i> = 29)	*23 (79%)	2% (7)	4 (14%)
Total (<i>n</i> = 130)	68 (52%)	17 (13%)	45% (35)

Data are presented as number of patients (%). PICC = peripherally inserted central catheter; Proper position: the catheter's tip resided anywhere between the origin of the innominate vein and the junction between the superior vena cava and the right atrium; Suboptimal: the catheter's tip was placed within the ipsilateral subclavian vein; Aberrant: the catheter's tip was placed in any other location; *n* = number of patients; * = significant difference in the incidence of proper PICC position between patients with left- and right-sided insertion ($P < 0.001$, Fisher's exact test)

findings are consistent with previously reported rates of aberrant positioning of PICCs ranging from 10%¹⁰ to 86%¹¹ in different patient populations.

The most common aberrant position of the PICC tip was in the right atrium in 15 (11.5%) patients. This aberration likely resulted from the inaccurate estimation of the depth of PICC insertion by measuring the surface length of the imagined course. Misplacement of the PICC in the right atrium is associated with an increased risk of arrhythmias¹² and potential for cardiac perforation.^{5,13}

The other common aberrant position of the PICC was the ipsilateral internal jugular vein. This location may have particular clinical significance in patients undergoing head and neck surgery. The PICC may become severed during surgical intervention, with a potential for vascular embolization if misplacement happens on the side of neck dissection.⁴ Furthermore, the PICC may also be unintentionally sutured to the wall of the jugular vein, precluding further PICC removal without performing surgical re-exploration.³

Free flap reconstruction is associated with an increased risk of postoperative thrombosis of the internal jugular vein. Thrombosis of the internal jugular vein was found in 14% of patients after this type of surgery.¹⁴ Unintentional insertion of the PICC into the internal jugular vein of the side of microvascular anastomosis may increase the risk of venous occlusion and compromise free flap survival.

We recommend placing the PICC on the opposite side to the neck dissection when feasible. Furthermore, the surgical team should always be made aware of the PICC placement; even if the catheter is inserted on the opposite side to surgical access, it could migrate to the contralateral subclavian and internal jugular veins, as we found in one of our patients. A surgeon may detect a malpositioned PICC and avoid potential complications by simple palpation of the internal jugular vein during the neck dissection.

Increasingly available bedside ultrasound devices may also facilitate recognizing inadvertent placement of PICCs into internal jugular veins.¹⁵

Interestingly, the PICC was found within the axillary vein in 14 (11%) patients. These findings agree with results of previously published reports.^{11,16} Inability to advance the PICC tip beyond the axillary vein may be related to resistance created by surrounding structures (clavicle, first rib, muscles). The PICC may also coil within the venous tributaries of the axillary vein, particularly if the affected arm is abducted during insertion.

We found that proper positioning of the PICC was more likely if it was inserted in the left rather than in the right arm (79% vs 44%, respectively; $P < 0.001$). Different groups of investigators reported similar findings^{17,18} as well as no difference with respect to the side of insertion.^{19,20}

The high incidence of aberrant PICC positions suggests careful evaluation of the risks and benefits of bedside insertion with no image guidance. Anesthesiologists usually consider the pre-existing co-morbidities and functional reserves of their patients when deciding to use central venous access. In our study, we found that advanced age and higher ASA classification were the main guiding factors for the decision to use PICCs. However, there is a growing body of evidence questioning the clinical usefulness of CVP monitoring in fluid management. Central venous pressure correlates poorly with heart preload and does not predict fluid responsiveness.²¹

In our study, patients in the PICC group and those managed without CVP monitoring received comparable amounts of fluids and had similar hospital length of stay (Table 2). These findings are not surprising because many published studies and meta-analyses show that CVP monitoring cannot significantly improve fluid management.² Moreover, no monitoring device, no matter how accurate or safe, can improve outcome unless monitoring is coupled with a specific goal-directed treatment protocol aimed to improve outcome.²² In conclusion, peripherally inserted CVP catheters have a considerably high incidence of aberrant positioning when placed without image guidance. The left-sided approach might be preferable to the right-sided approach because of the lower incidence of aberrant positioning. In patients undergoing FFR procedures, the risk-benefit ratio should be estimated carefully before using PICC insertion without image guidance. After bedside placement of a PICC, radiological confirmation of its position should be performed as soon as possible.

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Conflict of interests None declared.

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