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Peripheral intravenous catheter infiltration: anesthesia providers do not adhere to their own ideas of best practice

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Abstract

Study Objective—To survey anesthesia providers for their opinion on “best practice” in perioperative peripheral intravenous catheter (PIV) management, and to determine if they follow those opinions.

Design—Survey instrument.

Setting—Academic medical center.

Subjects—266 United States (US) anesthesia provider respondents [attending anesthesiologists, anesthesiology residents, anesthesia assistants, certified registered nurse-anesthetists (CRNAs), and student registered nurse-anesthetists (SRNAs)].

Measurements—Between May 2009 and October 2010 a national survey was distributed to individuals who provide intraoperative anesthesia care to patients. Results were gathered via the SurveyMonkey database.

Main Results—266 anesthesia providers from across the U.S. took part in the survey. The majority (70%) had less than 5 years’ experience. Nearly 90% of respondents cared for a patient with an intravenous (IV) catheter infiltration at some point during their training; 7% of these patients required medical intervention. Intravenous assessment and documentation practices showed great variability. Management and documentation of PIVs was more aggressive and vigilant when respondents were asked about “best practice” than about actual management.

Conclusion—There is no commonly accepted standard for management and documentation of PIVs in the operating room. From our survey, what providers think is “best practice” in the management and documentation of PIVs is not what is being done.

Keywords

Anesthesiologists; best practice; peripheral intravenous catheter use

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1. Introduction

Peripheral intravenous catheters (PIVs) are essential to the practice of anesthesia; however, they are not without complications, a common one of these being infiltration. These complications range from mild to severe, possibly requiring fasciotomy and skin grafting to the affected extremity, and may result in litigation [1]. A 2006 closed claims study by the ASA suggested that PIV complications accounted for 2.1% of all claims made from 1970 through 2001 [2]. While a majority of these complications appeared to be minor, several led to significant morbidity and even to mortality in the most significant of cases, and resulted in large monetary payouts for plaintiffs. Even with these dangers, there appears to be no standard of care in place for the treatment of PIVs in the operating room (OR) setting [1]. Our objective was to survey anesthesia providers for their opinions about “best practice” in perioperative PIV management, and to determine if they follow those opinions.

2. Materials and methods

Exempt IRB status was granted for a national [United States (U.S.)] survey distributed between May 2009 and October 2010 to Accreditation Council of Graduate Medical Education (ACGME) -accredited anesthesiology residency programs throughout the U.S. Potential survey recipients were identified based on attempts to provide a national representation of geographic location. Individual programs were contacted and the survey distribution was limited to the nine programs that expressed an interest in participating. A link to the 15-question survey (**Appendix 1**) was sent once to the departments identified during the above process. Each department was given instructions to distribute the survey link to individuals providing intraoperative anesthesia care of patients [attending anesthesiologists, anesthesiology residents, anesthesia assistants, certified registered nurse-anesthetists (CRNAs), and student registered nurse-anesthetists (SRNAs)].

Results were gathered via the SurveyMonkey database (SurveyMonkey, Palo Alto, CA, USA). The survey was structured to ensure anonymity of the respondents. At the close of the survey period, the data were exported to a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) for review. Data were analyzed using Fisher’s Exact test to determine statistical significance.

3. Results

A total of 266 anesthesiologists, residents, and CRNAs from across the U.S. took part in the survey. The majority (70%) had less than 5 years’ experience. Twenty-eight percent of respondents identified themselves as anesthesiologists, 36% as residents, and 36% as CRNAs. One respondent listed himself as “other”, without further specification. Nearly 90% of respondents cared for a patient with an intravenous (IV) infiltration at some point during their training, 7% of these infiltrations requiring medical intervention.

Intravenous assessment and documentation practices varied greatly. For cases in which there was provider access to the patient’s arms, 50% of respondents always visibly inspected the IV site, 10% rarely did so, and 0.4% never did; the balance of respondents answered “sometimes”. For cases without arm access, 6% of respondents reported that they still always visibly inspected the IV site, while 45% rarely did and 22% never inspected the site. When respondents were asked about palpation of the IV site, responses from those who had versus those who had no access to the arms were 22% versus 2% (always), 46% versus 27% (sometimes), 29% versus 46% (rarely), and 3% versus 25% (never), respectively. This finding suggests that IV assessment practices were severely hindered in cases with little to no access to the arms.

To further quantify the actual and best practice opinions, the survey presented three techniques for fluid administration: 1) via a simple “gravity” line with an IV bag hung suspended from a pole, 2) by pressure bag to augment fluid flow, and 3) by automated fluid pump. In terms of the timing of IV evaluation, providers stated that their actual practice was to check the IV at regular intervals 43%, 56%, and 40% of the time for IV to gravity, pressure bag, and fluid pump scenarios, respectively. Their opinions on “best practices” were that regular intervals should be used 81%, 76%, and 77% of the time for the same scenarios. Statistically comparing actual to best practice for each scenario by Fisher’s Exact test showed the difference to be significant at $P < 0.0001$ (Fig. 1). Thus, a respondent’s opinion of “best practice” suggested that a more vigilant management and documentation strategy for PIVs was warranted. Furthermore, those practitioners who believed that best practice was to evaluate the IV at regular intervals most often selected 15 minutes or less for catheters subjected to gravity only (46.2%), catheters on pumps (47.0%), and peripheral catheters under pressure bag (65.3%).

A majority of practitioners did feel that it was best practice to document IVs at some time during the case (68%). Including the group that would document IV function only if there was a problem, the number increased to 98.9%. However, only a minority of practitioners felt that routine documentation of IVs at any interval was a best practice (43.0%).

Interestingly, there was no difference in practice between those who had and those who had not experienced a major peripheral catheter complication requiring medical intervention during their careers (Fig. 2). This finding was true for catheters subject to gravity, pump, or pressure bag. There was also no statistical difference between these groups in the perception of best practice (Fig. 3).

4. Discussion

The correct placement of an IV catheter is an integral step in providing a safe anesthetic, yet the insertion site is often not checked after initial placement. In spite of providers’ lack of attention devoted to the monitoring of catheter function, the ASA Closed Claims Project has shown that complications secondary to peripheral IV catheters are a significant source of liability for anesthesiologists [2]. These complications include skin slough or necrosis (28%), swelling/inflammation/infection (17%), nerve damage (17%), and fasciotomy scars from compartment syndrome (16%) [2]. Compartment syndromes alone accounted for 22% of all IV catheter-related nerve damage cases. Moreover, approximately 54% of all peripheral catheter claims resulted in payment for injury, with the median compensation being \$38,400 [2]. Understanding that the role of peripheral IV infiltration in perioperative morbidity is significant, a higher level of vigilance on the part of the anesthesia provider is required.

Once an IV catheter has left the internal lumen of its vein, any fluid or medication administered parenterally enters the perivascular space, potentially causing injury to the patient. The injury suffered by the patient is the result of the combination of the site’s location, the physicochemical characteristics of the agent administered (pH, vasoconstrictor properties, osmolality, infusion pressure, and anatomical peculiarities), duration of soft-tissue exposure to the agent, and the patient’s general health [3]. The degree of damage caused by infiltration is affected by the nature of the substance - - vasoactive substances result in ischemia through severe vasoconstriction; concentrated electrolyte solutions cause ischemia by prolonging depolarization and contraction of precapillary and postcapillary smooth muscle sphincters; and hyperosmolar solutions lead to extensive fluid shifts and swelling via oncotic forces [3]. The resulting morbidity may range from increased patient discomfort or decreased satisfaction to phlebitis and superficial thrombosis, skin tears,

necrosis of the affected tissues [4], or even development of acute compartment syndrome [5–7].

Compartment syndrome is a potentially devastating acute condition in which the pressure within an osseofascial compartment increases, thereby reducing the perfusion gradient across tissue capillary beds and leading to cellular anoxia [8]. The end results include neurologic deficit, muscle necrosis, ischemic contracture, infection, delayed healing, and death [9]. The predominant pathological description states that an increase in compartment pressure results in an increase in venous pressure, leading to a decrease in the arteriovenous gradient.

Compartment syndrome occurs when the local arteriovenous gradient does not allow sufficient blood flow to meet the metabolic demands of the tissue [8]. In addition, the development of acute compartment syndrome requires a variable amount of time and should be considered if PIV management standards have been developed. Peripheral nerve tissue is more sensitive to an ischemic event than is muscle, with nerve function ceasing after 75 minutes of total ischemia. Muscle impairment typically occurs during the first 4 hours, with irreversible damage ensuing thereafter [6].

Compartment syndrome is primarily a clinical diagnosis that requires subjective feedback from the patient that is impossible to elicit during general anesthesia [9]. However, research has focused on the objective measurement of intracompartmental pressure for instances where the diagnosis is unclear [8]. In 1993, Heckman et al showed that the ischemic threshold of muscle is directly related to the differential pressure between the compartment and perfusion pressure [10]. In 1996, McQueen et al recommended that fasciotomy for decompression be performed if the differential pressure between the compartment and the diastolic blood pressure (DBP) drops to less than 30 mmHg. They reported that the adoption of this criteria prevented missing any cases of acute compartment syndrome in their study of 116 patients [11]. It is certainly conceivable that every means of IV fluid delivery used by clinicians can meet these described thresholds.

The most common methods of delivering IV fluids include hanging a bag of fluid from a pole or applying an inflatable pressure bag to a hanging bag of fluid. A hanging bag of fluid simply generates pressure via the height of the fluid column; thus we developed the equation:

$$\text{Pressure (mmHg)} = 0.7418 \times \text{Height of Fluid Column (cm)} - 6.109$$

and confirmed its accuracy by measuring the pressure generated at different heights with a transducer. An IV bag hung at a typical height of 6.5 feet (198 cm), with the patient at 3 feet (91.4 cm), generates a pressure of 73 mmHg; a bag raised to 8 feet (244 cm) to facilitate flow generates 107 mmHg of pressure of 107. Using the data of McQueen et al, either of these pressures may place a patient at risk of an infiltration, causing compartment syndrome. Not only do these pressures exceed the 30 mmHg differential from DBP, but in some cases they also exceed systolic blood pressure. Adding an inflatable pressure bag to a hanging bag of fluid simply adds the force from the pressure bag (typically around 300 mmHg) to the pressures generated by the hanging bag of fluid alone.

Alternative ways of delivering fluid include a manual squeeze or automated fluid pump. A tubing set with a squeeze pump generates pressure via the height of the fluid column in addition to the pressure applied by the user during a hand squeeze. When we attempted to measure the potential pressure developed by a manual squeeze, our pressure transducer recorded pressures exceeding its maximum of approximately 350 mmHg for even “gentle” squeezes. As for automated fluid pumps, the literature for our Alaris PC 8100 pump

(CareFusion Corp., San Diego, CA, USA) states that at typical intraoperative infusion rates, 525 mmHg represents the most common maximum pressure limit. The manufacturer addresses infiltrated IVs, noting that “soft occlusions” may not be detectable since they may not produce enough pressure to reach the alarm limit. Because of these settings, the pumps cannot be relied on to alert a practitioner to developing compartment syndrome.

Despite the known risk of IV catheter infiltration and the multiple case reports that have been published describing the adverse outcomes of such events, no standards yet exist regarding intraoperative recording intervals for the appearance of the IV site or for the flow rate of a gravity infusion. As acute compartment syndrome obliterates peripheral nerve function after as little as 75 minutes of ischemia [6], the anesthesia provider may be placing the patient at significant risk by not checking the IV site.

Intravenous infiltration is most directly assessed visually or by palpation to explore swelling, blanching of the skin, dependent edema, temperature changes localized around the catheter, fluid leaking from under the catheter dressing, evaluating for retrograde blood flow through the tubing after lowering the infusion bag and applying light proximal pressure, or by failure to stop fluid flow by occluding the vein with finger pressure just proximal to the insertion site. Intravenous injection of indigo carmine or the use of a penlight (subcutaneous fluid shows a large, diffuse circle of light on transillumination with a penlight) also may aid in the assessment of questionable catheter placement [12]. If direct assessment is not possible, IV infiltration may be suspected when there is a decrease in the flow rate of a gravity infusion (due to the increased resistance of the perivascular tissue), when the patient fails to respond to medications administered through the IV, or when application of a tourniquet on the associated limb fails to stop a gravity infusion. A standard procedure and interval for PIV assessment may decrease the complications from these catheters.

As shown by the ASA Closed Claim database, the most common surgical cases associated with claims related to compartment syndromes were those in which the arms were tucked because the anesthesia provider could not visualize or tactilely monitor the peripheral catheter [2]. As the complications of infiltration pose significant morbidity for the patient, vigilance of the anesthesia provider is crucial for warning signs of infiltration, including a slowing in the IV drip rate. The anesthesia provider must maintain a low threshold for visually checking the IV insertion site [2]. In addition, as electronic records with reminder alerts become more ubiquitous, their use may be beneficial in this area of patient safety.

Because our study consisted of a survey aimed at a specific group of providers, there are several weaknesses. As many residency program directors receive multiple survey requests, we felt it would be beneficial to focus on programs that stated they were interested in responding. This limited the number of surveys sent out, but insured that we would receive responses from a variety of geographical areas. By allowing the programs the authority to determine who was included (usually via group emails to their department), we believe we maximized the total number of respondents; however, as a result we were unable to calculate a response rate.

A selection bias also may have been introduced: the majority of our respondents stated that they were in practice for less than 5 years (reflecting the fact that surveys were sent only to academic departments). In addition, no distinction was made between a PIV started by the respondent versus one started by another practitioner. Finally, we chose to use descriptors such as “always” and “sometimes”. This practice required some interpretation by the respondent, and may have skewed the results. We feel that our results show a disconnect between our respondents’ thoughts of “best practice” and their actual practice, and that these

results provide a strong foundation for the development of a large-scale study of all anesthesia providers, or discussion in a national patient safety forum.

There is no commonly accepted standard for management and documentation of PIVs in the OR. From our survey, what our respondents think is "best practice" in the management and documentation of IVs is not what is being done or being taught in the OR. Peripheral intravenous catheter infiltrations are a significant problem, considering that over 90% of the respondents had experienced one during their career. Overall, 68% of survey respondents felt that it would be best practice to assess PIVs routinely across the three methods of delivery examined in this survey. It is possible that if the respondents' "best practice" opinions were followed, there would have been significant reductions in the occurrence and severity of PIV infiltrations due to earlier detection and the resulting prevention of them from becoming medically significant. Ideally, a standard of care for PIV management and documentation is developed, giving providers confidence that their practice is consistent with their colleagues'.

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Fig. 1. Comparison of actual to best practices among anesthesia providers. The proportion of respondents who felt that best practice was to check the intravenous (IV) site at a regular interval was significantly higher than their own actual practice.

Fig. 2.

Comparison of the actual practice of those providers who had a major peripheral intravenous (IV) catheter complication with those practitioners who did not showed no statistically significant difference.

Fig. 3. Comparison of the opinions of best practice of those providers who had and who had not had a major peripheral intravenous (IV) catheter complication showed no statistically significant difference.