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Fluoroscopy Study of Peripheral Nerve Block Catheter Tip Movement–Its Clinical Implication in Guiding Catheter Adjustment

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Abstract

Background: Continuous peripheral nerve block catheter has been widely used clinically. A small percentage of catheters usually need adjustment after placement. However, there is no study on how to adjust catheter in the literature.

Methods: Twelve fresh pork legs were randomly allocated into one of two groups, perineural catheter advanced 5 cm or less beyond needle tip (N=6), or more than 5 cm beyond needle tip (N=6). For both groups, ultrasound guided sciatic nerve block was performed with the "in-plane" approach.The anatomic landmarks and the locations of the sciatic nerve block equate to the Labat approach in humans. Thirty milliliter of normal saline was used to dissect the epineuron space before threading 20G soft non-stimulating catheter. The catheter was pulled back in one-centimeter increments at the level of the skin while the location of the tip of the catheter was identified by fluoroscopy after each centimeter pull back. The main outcome was the catheter tip movement.

Results: The catheter tips advanced either cephalic or caudally without dominance trend, while most catheter tips located superficially to the needle tip (11 out of 12). In T<5 cm group, the catheter tips movements were 0.46 ± 0.10 cm per centimeter pull back.In T>5 cm group, the catheter tip movement was initially 0.17 ± 0.11 cm per centimeter pull back, then increased to 0.25 ± 0.12 cm once the catheter tip was less than 5 cm beyond the initial depth of needle tip.

Conclusions: We recommend that adjustment of the CPNC should base on the initial depth of the needle tip since the initial catheter tip movements among these over threaded catheters are very limited, and it would not be efficient in clinical practice to adjust peripheral nerve block catheter by pulling by centimeter increment.

Keywords: Peripheral nerve block catheter; Tip movement; Fluoroscopy

Introduction

Peripheral nerve blockade is an effective and proven method of providing anesthesia and analgesia to many surgical patients. Continuous Peripheral Nerve Catheter (CPNC) further extends the scope of care we could offer to our patients by extending the duration of post-operative analgesia. There are two basic types of catheters, stimulating catheter and non-stimulating catheter. The approaches of placing non-stimulating catheters are divided into two basic categories: direct thread technique and hydro-dissection before threading technique. The hydro-dissection before threading technique is more popular among anesthesiologists, mainly due to its effectiveness and efficiency. There is no consensus among anesthesiologists in terms of ideal distance of catheter advancement beyond the needle tip, while most practicing anesthesiologists tend to thread 5-10 cm beyond the needle tip due to concerns of potential dislodgement.

CPNC requires continuous management by acute pain service after placement. The percentages of technical problems related to catheters and devices are common. Capdevila et al. reported a 17.9% technique problem among 1416 catheters [1]. Bergman et al. reported a 7.7% technical difficulty with 405 axillary nerve block catheter placements [2]. Although there was no detailed information of how many of these catheters had to be repositioned, the incidences of the catheter tip migration are not rare. The method of troubleshooting an existing while failing CPNC depends on each individual anesthesia provider's experience. In principal, new catheters could replace failed CPNCs. However, it requires more resource to replace an existing catheter. In addition, it could also be very challenging to identify the appropriate nerve(s) under ultrasound guidance and/or nerve stimulation due to the distortion of surrounding anatomy from recent catheter placement and/or existing local anesthetics. Therefore, most anesthesia providers would attempt to adjust the existing catheter before replacing it.

What is the most effective and efficient method to adjust the catheter? What is the appropriate length to retract a CPNC during adjustment? To our knowledge, there is no studies of reference on adjusting peripheral nerve catheters in the current literature. Therefore, we conducted this prospective observational study to investigate the motion of catheter tips under fluoroscopy immediately after placement and during sequential manual adjustments in a pork sciatic nerve block model.

Materials and Methods

The institutional review board at the University of Pennsylvania (Philadelphia, Pennsylvania, USA) exempted this study. We used fresh pork legs as our study model because of the anatomic similarity between human and pig. Fresh pork legs weighting 15 to 20 LBS were purchased from the local grocery store. After placing the pork legs in

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a prone position, Sonosite S-Series ultrasound machine with C60 low frequency probe was used to identify the sciatic nerve at a posterior position, achieving a sonographic view similar to one identified by the Labat approach for sciatic nerve block in humans. The ultrasound identification of the pork sciatic nerve was confirmed by dissection and direct visualization in two separate specimens. Next, using an in-plane ultrasound guidance approach, a 10 cm 18G Contiplex Tuohy needle (B. Braun, Germany) was inserted and advanced under ultrasound (US) guidance with a target location at the inferior lateral aspect of the sciatic nerve. The bevel of the needle was pointed towards the sciatic nerve with an additional cephalic twist. Upon satisfactory needle position, 30ml of normal saline was used to hydro-dissect the epineuron space under US guidance. Last, a 20G soft non-stimulating Contiplex catheter (B. Braun, Germany) was threaded through the Contiplex needle.

There were two study groups. In Group T<5, 5 cm of catheter was threaded beyond the tip of Contiplex needle, while in Group T>5, the catheter was continuously threaded through the Contiplex needle until either it would not thread further or the catheter was close to around 30 cm at the adaptor hub. There were total of six pig legs per group. All catheters were pre-filled with Visipaque 320 (GE Healthcare Inc., USA) to improve its visualization under fluoroscopy. After threading the catheter to the predetermined length, both the needle and catheter were kept in place while the entire specimen was transferred and placed prone under fluoroscopy. Two fluoroscopic machines were placed at 90-degreeangle to each other with respect to their cross-sectional planes. The goal of this arrangement is to capture the location of the tip of needle and the tip of catheter in both the sagittal and coronal plane views. One additional 5 cm needle was placed at same depth of the catheter and the needle complex to serve as an internal control ruler under fluoroscope for calibration purposes. After recording the initial locations of the tip of the Contiplex needle and the tip of the catheter, the needle was removed from the pork leg with only the catheter in situ. The catheter was then pulled back in one-centimeter increment while the location of the catheter tip was identified by fluoroscopy after each centimeter pull back. All measured locations were recorded in two dimensions according to the sagittal and coronal views provided by fluoroscopy. Statistic analysis on the data collected was performed by pairwise Student t test.

Results

The initial location of the catheter tips were relatively close to the Contiplex Tuohy needle tip with a majority located superficially to the needle tip (11 out of 12 catheters, Figure 1A). There were seven catheters threaded cephalic along the assumed path of sciatic nerve while 5 catheters were threaded caudally (Figure 1B). The initial position of the majority of the catheter tips was within 3 cm to the assumed axis of the nerve path (9 out 12 catheters).

The movements of the catheter tips were recorded sequentially under fluoroscopy while the catheter was pulled back one centimeter at a time. In Group T<5 (catheters threaded <5 cm beyond the needle tip), the catheter tips movements were 0.46 ± 0.10 cm per centimeter pull back. In Group T>5, (catheters threaded >5 cm beyond needle tip), the catheter tip movement was initially 0.17 ± 0.11 cm per centimeter pull back. This movement increased to 0.25 ± 0.12 cm once the tip is less than 5 cm beyond the initial depth of needle tip (P=0.042).

Catheter tip motion in the over-thread group (>5 cm) demonstrated relatively smaller incremental movements (Figures 2A and 2B). In contrast, the catheter tip movement among the normal thread group (<5cm) shows relative linear relationship throughout, with significantly larger movements per pull back than the over-threaded catheters (Figures 2C and 2D).

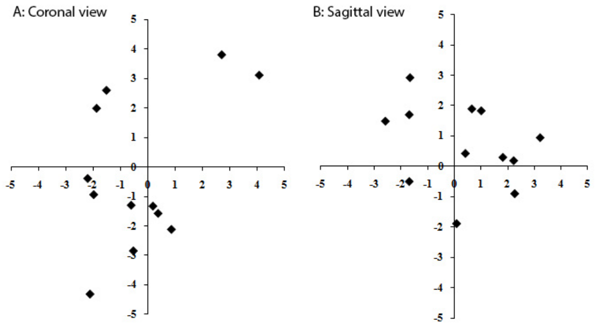

Figure 1: The Location of Catheter Tips. Catheter tip location was calculated from the sagittal view and coronal view images. All measurements were in centimeter and calibrated with 5 cm internal control ruler. X-Y intercept point represents the location of the Contiplex needle tip under fluoroscope.

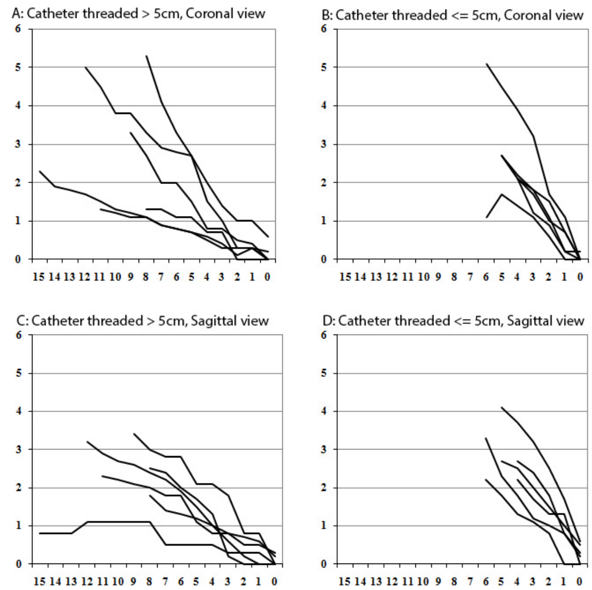

Figure 2: The Movement of Catheter Tips under Fluoroscope. Each line represents one sample. Sagittal view and coronal view are shown separately. X-axis represents the distance of catheter tip beyond the original Contiplex needle tip as calculated by catheter marks at skin. Y-axis represents the distance of catheter tip to the original Contiplex needle tip as calculated under fluoroscope.

Discussion

Continuous Peripheral Nerve Block Catheter (CPNC) provides effective anesthesia and analgesia with the advantage of flexible duration. However, CPNC requires constant management and troubleshoot. There is no consensus or guideline in regards to how to troubleshoot CPNC.

We first reviewed existing literature on epidural catheter in search of generalizable information on catheter characteristics.The epidural catheters could be either cephalad or caudal although the Tuohy bevel is usually pointing cephalad [3-5]. A computed tomography study showed that catheter tips were more often lateral to the dura close to the intervertebral foramen with significant inter individual variability [6]. While studies on epidural catheter provided valuable information on the dynamic characteristics of catheters in general, there are still fundamental differences between the epidural space and the artificially dissected peripheral nerve space.

There is no existing peripheral nerve space for catheter placement. The anatomic structures around peripheral nerves include endoneurium, perineurium, epineurium, and varies fascia layers. The speculated ideal location for peripheral catheter tip is immediately outside of the epineurium. Alternatively, acceptable locations for placement also include inside the fascia layers surrounding the peripheral nerve, which allows local anesthetics to diffuse to the nerve. There are different peripheral nerves with different surrounding anatomical characteristics. These anatomical characteristics also vary at different positions along the path of the same peripheral nerve. It is reasonable to assume that all these characteristics could affect the placement and further management of the peripheral nerve block catheter.

Our study focuses on the relative motion of catheter tip during a pull-back adjustment process under direct fluoroscopic observation. The results suggest that over-threading catheter improves the fixation of catheter tips. Adjustment of an over-threaded catheter results in relatively small movements of its tip per centimeter adjustment, which could be due to the uncoiling process along the length of the catheter tubing. Interestingly, the motion of the over threaded CPNC tip is significantly smaller comparing to the regularly threaded catheter even if it is pulled back to within 5 cm beyond the initial needle depth. One explanation is that a relatively fixed position of the catheter tip in the over threaded situation limits its movement. The CPNC tip motion is significantly more dynamic with the regularly threaded (<5 cm) CPNC.

In summary, we recommend that the adjustment of catheter should be more aggressive and reference to the original depth of needle. For example, we would recommend considering pull the over threaded catheter until it is 4-5 cm beyond the initial needle tip depth with the first attempt during troubleshoot, and then test its efficiency. This strategy would be most efficient in our clinical practice than gradually pulling catheter and intermittent bolus testing.

Our study has its limitations. First, we used pork leg as the model to investigate the catheter tip movement. Although the anatomy is similar between pig and human in regards to sciatic nerve, there are differences between pig and human, as well as between live pig model and fresh pork leg. Second, sciatic nerve is located deeply and surrounded by multiple tissue layers. This model might not be applicable to other types of peripheral nerve catheters, especially in the upper extremities, which are more superficial and prone to dislodgement. Third, we used fluoroscopy approach to study the catheter tip movement. We assumed that the initial Contiplex needle tip under fluoroscopy represents the relative location of the actual nerve without being able to observe and measure the sciatic nerve directly. Fourth, we studied the anatomical position of the catheter tip in relation to the sciatic nerve location. However, this might not necessarily correlate with local anesthetic diffusion and its clinical efficacy. Follow up studies on live animal model might provide more insights in the clinical significance of catheter tip location to nerves.

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