Pharmacokinetic profile and dermatomal coverage of the erector spinae plane block - a comparison of bolus dosing and continuous infusion

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Introduction

Background

Muscle plane blocks are a fairly new regional anesthesia technique and are increasing in popularity. The most recent muscle plane block, termed the erector spinae plane (ESP) block, was developed to optimize pain control for thoracic surgery while minimizing the risks associated with paravertebral and epidural blocks. Numerous case reports have advocated for its use[1-4].

Significance of the research

In comparison to traditional neuraxial and peripheral nerve block approaches, a successful ESP block requires a higher volume of local anesthetic. Therefore, the optimal volume to produce analgesia from an ESP block may result in a plasma local anesthetic concentration that approaches toxic levels. Pharmacokinetic studies have been performed with muscle plane blocks, such as the quadratus lumborum block and transversus abdominus plane block[5,6]; however, the pharmacokinetic profile of the ESP block has not yet been measured or studied. This study will demonstrate how quickly and closely toxic levels are reached when a routine dose of ropivacaine is given for the ESP block and will also assess for areas of numbness created by the ESP block when routine doses are administered.

Specific aims of the project

- Create plasma ropivacaine concentration-time curves after performance of an ESP block via bolus and continuous infusion into the ESP compartment. The concentration-time curves will include the peak serum concentration of ropivacaine (Cmax) and the time required to reach maximum plasma concentration (Tmax).
- Determine the dermatomal distribution and duration of analgesia created when ESP block is performed via ropivacaine bolus versus continuous ropivacaine infusion.

Methods

Study design

This study will use clinical laboratory tests to objectively measure serum ropivacaine levels after an erector spinae plane (ESP) block is performed on patients undergoing cardiac surgery. During an ESP block, ropivacaine is typically injected into a muscle plane that is deep to the erector spinae muscle and superficial to the transverse process of the thoracic vertebral body; subsequently, the ropivacaine is absorbed into the bloodstream, at which time measurements can be taken. Secondary measurements will include distribution and duration of numbness created by the ESP block.

Description of procedures

The ESP block procedure - participant consent will be performed on the day of surgery by one of the research investigators in the pre-operative surgical unit (PSU). Randomization is not required because all participants will be undergoing the same protocol. All participants will also be undergoing cardiac surgery by the same surgeon. Routine care will be performed for the placement of the ESP block and is described as follows: the ESP block will be performed by the acute pain service, which will have members that are not involved with the research. Adequate block placement will be confirmed by one of the investigators via ultrasound images that are captured during the procedure. The participant, who is already in a patient gown with an intravenous line (IV) in place, will be positioned sitting on the side of the patient bed. Vital sign monitoring with pulse oximetry and blood pressure cuff will be connected. The participant will be given intravenous midazolam to reduce anxiety and enhance comfort during the ESP block procedure. Full aseptic precautions will be taken with personal protective equipment and bactericidal preparation with chlorhexidine. An ultrasound probe will be placed lateral to the patient's upper back and the ideal location of medication injection will be identified on an ultrasound image (which is superficial to the transverse processes of the thoracic vertebral bodies and deep to the erector spinae muscle). The skin will be made numb with lidocaine prior to insertion of a larger needle (Tuohy needle); the proceduralist will direct the Tuohy needle to the desired target under ultrasound guidance and 25 cc 0.25% ropivacaine will be delivered through that needle. A continuous nerve catheter will then be inserted through the Tuohy needle to allow for continuous delivery of medication if desired. The Tuohy needle will be removed, and the nerve catheter will be secured in place with adhesive dressing. Cardiac surgery will require bilateral (left and right) nerve catheter placement, and therefore, upon completion of one side, the ESP block will be performed on the other side. The estimated time needed for a bilateral ESP block procedure is 30 minutes. After the completion of the ESP block procedure, the participant will undergo their planned cardiac surgery procedure, which typically takes many hours.

Initiation of continuous nerve catheter infusions (alteration of standard care) - this component of care will be different than routine care. Nerve catheter infusions are typically initiated at the end of the surgical procedure at a concentration and rate of 0.2% ropivacaine at 8-10 cc/hr.

The study protocol will direct the nerve catheter infusions to run at 1 cc/hr; this rate will allow the nerve catheters to remain open and patent but will not significantly interrupt or alter the quality of the research data collection. The operating room team and ICU staff will be notified about the patient's participation in the study and will have information available regarding the alterations from routine practice that would be required for this study.

Research protocol, part 1 - the research protocol and data collection will begin on the afternoon of post-operative day 1 (the day after surgery) in the cardiac surgery intensive care unit (CSICU). Typically, cardiac surgery patients will be sedated and have a breathing tube in place until the morning of post-operative day 1. This delayed timing of the study will allow the participant to stabilize after removal of the breathing tube. Although written consent has already been obtained, a research investigator will obtain a verbal reaffirmation from the participant and update the CSICU team before proceeding.

Per routine, the participant will have vital sign monitors connected and have an arterial line in place that will allow for collection of blood samples for laboratory testing. The nerve catheter infusions will be suspended and the research protocol will begin in the CSICU as follows: the investigator will administer 25 cc 0.25% ropivacaine through each nerve catheter (totaling 50 cc 0.25% ropivacaine) and record the time of administration on a data collection sheet. Either the investigator or study assistant will collect arterial blood samples at the following intervals after the medication bolus: 10 minutes, 15 minutes, 30 minutes, 45 minutes, 60 minutes, 90 minutes, 2 hours, and 4 hours. The blood samples will be labeled with a patient ID sticker and will also contain the study ID number and the time interval that corresponds with the blood sample. The samples will be stored in a designated ice cooler that will be delivered to the clinical laboratory.

During this first portion of sample collection, the secondary outcome of dermatomal analgesia and duration will be assessed. At the 60-minute interval, a study investigator will test areas of numbness performing a pinprick test and using a dermatomal map to mark the areas of numbness. For the pinprick test, the investigator will use a pointed object that is sharp enough to elicit a sharp sensation but blunt enough that it does not cause skin damage; the participant will be asked to provide comparison of the sensation of the pointed object when it is applied to an area that is not expected to be numb (like the palm) versus an area that is expected to be numb (like the chest and thorax). At the 90-minute, 2 hour, and 4 hour intervals, the participant will be asked if the numbness from the nerve block has gone away. If the resolution of numbness occurs between the time intervals, the participant will be asked to look at the clock and remember the time at which the difference was felt. It is expected that at the 4-hour interval, the serum ropivacaine level will be approaching or have reached the baseline level before the bolus was given.

Research protocol, part 2 - at the 4-hour interval (4 hours after the initial bolus), both nerve catheter infusions will be resumed at a concentration and rate of 0.2% ropivacaine at 10 cc/hr. Either the investigator or study assistant will collect arterial blood samples at the following intervals after the start of the infusion: 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, 24

hours. Dermatomal analgesia assessment will be performed by one of the research investigators at the 24-hour mark. After this assessment, the research protocol will be considered complete and routine care by the CSICU and acute pain service will resume. The researchers will collaborate with the health care teams during the study protocol if this becomes necessary to maintain patient safety and comfort.

The collected blood samples are viable for one week if they are refrigerated and one month if they are frozen. Free and total ropivacaine levels will be determined for each sample by the clinical laboratory and this information will be distributed to the research investigators in a way that protects patient health information and will be recorded securely onto a data collection sheet. The data for this sheet can then be used for statistical analysis and creation of a pharmacokinetic profile for the ESP block (both bolus and infusion curves).

Data analysis

A two-sample Kolmogorov-Smirnov test will be used to determine the difference between the distributions of the bolus arm and the infusion arm. Tmax and Cmax of the two arms will be analyzed with an unpaired t-test. A logrank test will be used to assess the difference between the duration of analgesia created by the bolus arm and the infusion arm.

Institutional board approval

The protocol has been approved by Virginia Commonwealth University Institutional Review Board (Study ID HM20014803).

Literature cited

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