



# Karolinska Institutet

Institutionen för Fysiologi och Farmakologi

## Ultrasound-guided regional anesthesia in children and adults

### Aspects on central and peripheral blocks

#### **Akademisk avhandling**

som för avläggande av medicine doktorsexamen vid Karolinska Institutet  
offentligen försvaras i Skandiasalen, Astrid Lindgrens Barnsjukhus,  
Karolinska Universitetssjukhuset Solna, fredagen den 25 maj 2012, kl 9.00 av

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# ABSTRACT

The universal use of regional anesthesia has previously been hampered by fundamental factors, e.g. excessive failure rates, inability to detect anatomical variations and fear for unintentional tissue damage; all due to the inherent imprecision of previous localization techniques. The introduction of ultrasound guidance (USG) has now made it possible to circumvent previous limitations by allowing real-time visualization of the block procedure. The aim of the current thesis project was to develop and evaluate a new USG nerve block and to investigate some mechanistic issues related to the established pediatric caudal block technique by use of ultrasound (US) imaging.

**Infrapatellar nerve (IPN) block:** This block has not previously been described as an USG technique. In *Study I* a USG IPN block was performed in 10 adult volunteers using a prospective, observational design and various block characteristics were assessed. The IPN could reliably be visualized by US and the USG IPN block was found to produce an anesthetized area of the anterior aspect of the knee with a median duration of 30 hours. In *Study II* the clinical usefulness of the USG IPN block was evaluated using a prospective, randomized, double-blind, placebo-controlled design involving 64 patients undergoing outpatient anterior cruciate ligament repair. The primary aim of this study was to evaluate the incidence of a pain score of  $>3$  both at rest and on muscular activity. The addition of an USG IPN block to an established multi-modal analgesic regimen was found to result in a reduced incidence of a pain score of  $>3$  during the latter part of the 24 hour observational period, and was also associated with an increased number of sleep hours.

**Caudal blockade:** US scanning in young individuals allow for real-time visualization of the spread of LA within the spinal canal, something that previously has been impossible. Using a prospective, age-stratified, observational design the US assessed spread of the local anesthetic (LA) was determined in 47 children receiving a high-volume ( $1.5 \text{ mL kg}^{-1}$ ) caudal block in *Study III*. The observed spread was subsequently correlated to patient characteristics. A significant inverse relationship was found between patient characteristics and the maximal cranial level reached by the LA. However, due to unknown reasons the cranial spread assessed by immediate US visualization was found to be in poor agreement with previously published predictive equations. In an attempt to unravel the potential mechanism responsible for this unexpected difference, the pattern of secondary intraspinal spread of LA was observed by US during a 15 minute post-injection period in 16 infants  $< 6$  months of age in *Study IV*, which also included measurements of intraspinal pressure and cutaneous testing of the dermatomal block level. The median US-assessed cranial spread was Th10 and Th8 at 0 and 15 min, respectively, and the sensory level at 15 min was Th4. The caudal injection was initially found to compress the terminal part of the dural sac, later followed by a partial re-expansion as epidural pressure was returning towards pre-injection values. An intrasegmental redistribution from the dorsal to the ventral compartment of the epidural space was also observed.

**Conclusions:** An USG IPN block reliably produces prolonged anesthesia of the anterior aspect of the knee and improves pain relief and sleep after outpatient knee surgery compared to the use of a multi-modal state-of-the-art analgesic regimen alone. US assessment of caudal spread of LA show that the cranial level reached is inversely related to the age, weight and height of the child. Two separate patterns of secondary intraspinal spread of LA can be identified by US: horizontal intrasegmental redistribution and longitudinal cranial spread. A bi-directional movement of cerebrospinal fluid (coined 'the CSF rebound mechanism') does help explain the difference between the initial ultrasound-assessed cranial level and the final level determined by cutaneous testing.