Chapter 1: Introduction

Regional anaesthesia has increased in popularity in recent years (Clergue *et al.,* 1999). This was prompted by two significant events. Firstly, the realisation that children do feel pain and require pain relief like adults; and secondly, that avoiding general anaesthesia in premature babies may have major advantages.

With the increased survival of premature infants in recent years, the number of premature neonates presenting for surgery has increased. These premature neonates present with either chronic or acute defects that urgently need to be corrected. The risk of general anaesthesia is significant in these patients as they are at a greater risk of developing respiratory failure and postoperative apnoea compared to term infants of the same age (Welborn *et al*., 1986). Recent concerns regarding the deleterious effects of general anaesthesia on the developing brain further justifies the use of regional anaesthesia in this vulnerable age group (Sun *et al.* 2008).

The use of regional anaesthesia therefore may have considerable advantages not only in premature neonates but also in infants, children and adults. The stages of development can be classified as follows: Stage 1: Neonate or newborn (0-30 days), Stage 2: Infant or baby (1 month-1 year), Stage 3: Toddler (1-4 years), Stage 4: Childhood (prepubescence) (4-12 years), Stage 5: Adolescence and puberty (12-20 years), and Stage 6: Adulthood (21 years - death), which can be subdivided into early adulthood (21-39 years), middle adulthood (40-59 years) and advanced adults/senior citizen (older than 60 years) (Jones, 1946).

1.1) A brief history of paediatric regional anaesthesia

The 19th century was a time when fundamental changes were made in the concepts regarding medicine. This is especially true for the speciality of regional anaesthesia. It is also the period regarded as the birth of modern regional anaesthesia (Bonica, 1984; Dalens, 1995). The thought that the heart is the centre for pain reception was discounted and Bell in 1811 and

Magendie in 1822 showed that both motor and sensory impulses were relayed by the nerve tracts. By 1840, Muller established that the brain is the centre for perception and received all sensory information, including pain stimuli (Dalens, 1995).

August Bier is commonly regarded as the “father of regional anaesthesia” and discovered the “cocainization of the spinal cord”, using a spinal anaesthetic technique (Fortuna & de Oliveira Fortuna, 2000). Since then, the regional anaesthetic techniques of the time included spinal, caudal epidural and supraclavicular brachial plexus blocks. These procedures gained enthusiastic acceptance by the anaesthesiologists of the time (Bainbridge, 1901; Farr, 1920; Campbell, 1933). However, these procedures gradually fell into disuse and almost came to a complete halt after the Second World War. This was mainly due to the development of new anaesthetic agents and improved techniques for general anaesthesia, which were safer and more reliable to use.

The nineteen seventies saw a re-emergence of paediatric regional anaesthesia. Studies conducted by Lourey and McDonald (1973), Kay (1974) and Melman *et al.* (1975) caused a resurgence in the popularity of paediatric regional anaesthesia. The concept that regional and general anaesthesia can be used in a complimentary fashion, rather than being in contention with each other, also gained increasing acceptance (Dalens, 1995).

This increase in regional anaesthesia could be attributed to the constant refinement, and/or development of new techniques. Research into newer, safer and better local anaesthetic solutions, as well as the use of continuous infusions through pumps, has offered new ways of providing pre- and post-operative analgesia to patients scheduled for paediatric surgery (Cook *et al.*, 1995). With the above-mentioned advances in the field of anaesthesiology, the need for a strict protocol for administration, with reliable equipment, well-trained and alert personnel, become even more important (Fortuna & de Oliveira Fortuna, 2000).

1.2) The importance of clinical anatomy in regional anaesthesia

Despite all the opportunities in medical research today, as well as the advances made in medical technology, the effective performance of clinical procedures still rests on a solid anatomical basis. This is even more important for medical practitioners in developing countries where technology is often lacking and they are dependent on their anatomical knowledge for the successful performance of clinical procedures (AACA, EAC, 1999).

The practice of regional nerve blocks relies heavily on a sound knowledge of clinical anatomy (Winnie *et al.*, 1975). This is especially true for anaesthesiologists who perform these blocks on paediatric patients (Bosenberg *et al.*, 2002). Clinical procedures, such as regional nerve blocks, which either fail to achieve their objective or that result in complications, can often be linked to a lack of understanding, or even misunderstanding, of the anatomy relevant to the specific procedure (Ger, 1996; AACA, EAC, 1999).

Winnie and co-workers (Winnie *et al.*, 1973) states that no technique could truly be called simple, safe and consistent until the anatomy has been closely examined. This is quite apparent when looking at the literature where many anatomically based studies regarding regional techniques have resulted in the improvement of the technique, as well as the development of safer and more efficient methods. Anaesthesiologists performing these procedures should have a clear understanding of (a) the anatomy, (b) the influence of age and size, and (c) the potential complications and hazards of each procedure to ensure good results (Brown, 1985). Ellis and Feldman (1993) stated that anaesthesiologists required a particularly specialised knowledge of anatomy, which in some cases should even rival that of a surgeon. There is however a distinct lack of studies focusing on the anatomy of a paediatric population and relating it to a clinical setting (van Schoor *et al.*, 2005). The anatomy described for paediatric patients are in most instances, obtained from adults and could be flawed (see Table 3.1 for an example).

Performing regional anaesthetic procedures on paediatric patients have some additional complications and problems associated with it. Many anaesthesiologists may not be comfortable with working on a dose/weight basis. Most importantly, many anaesthesiologists not used to working with paediatric patients may lack the knowledge of the relative depths or position of certain key anatomical structures, as it is known that the anatomy of children of different ages may differ to a greater or lesser degree from that of adults (Bosenberg *et al.*, 2002, Brown, 1985, Brown & Schulte-Steinberg, 1988, Katz, 1993). A thorough knowledge of the anatomy in children is therefore essential for successful nerve blocks and it cannot be substituted by probing the patient with a needle attached to a nerve stimulator, while the effective use of ultrasound requires a sound knowledge of the anatomy of the specific region. The anatomy described in adults is not always, and in most instances not applicable, to children of different ages as anatomical landmarks in children vary with growth. Bony landmarks (e.g. the greater trochanter of the femur) are poorly developed in infants prior to weight bearing. Muscular and tendinous landmarks commonly used in adults, tend to lack definition in young children partly because of poorer muscle development (Bosenberg *et al.*, 2002), but also because they require patient cooperation to locate them. Most children are under sedation or general anaesthesia when the nerve block is being performed (Bosenberg *et al.*, 2002, Armitage, 1985). Finally, classical anatomical landmarks may be absent or difficult to define in children with congenital deformities (Bosenberg *et al.*, 2002).

1.3) Indications and limitations of paediatric regional anaesthesia

Regional anaesthesia has advantages over general anaesthesia since it covers not only the intra-operative but also the postoperative period. Regional anaesthesia can be used to treat both acute and chronic pain and, in addition, it also provides both sympathetic and motor blockades (Saint-Maurice, 1995). Like all clinical procedures, the indications of regional anaesthetic techniques is based on well-established criteria, such as patient safety, quality of analgesia, duration of surgery, and whether it is a minor or major surgical procedure (Melman *et al.*, 1975; Armitage, 1985; Saint-Maurice, 1995, Markakis, 2000, Wilder, 2000).

Indications should not be decided by the subjective preferences of the anaesthesiologist or on the basis of mastery of the specific technique (although this is vital when the procedure is actually performed), but solely on whether the technique is required by careful examination of the indications (Saint-Maurice 1995). In order to select the best anaesthetic technique available, the benefits and risks of the regional nerve block should first be weighed against the advantages and disadvantages of all other available techniques of analgesia (Dalens & Mansoor, 1994).

1.3.1 General indications of regional anaesthesia

Patients often have certain medical conditions, where the use of regional nerve blocks would be an advantage, these include:

1.3.1.1 Disorders of the respiratory tract

The presence of respiratory diseases is in most cases (except the interscalene block, which has a high incidence of blocking the phrenic nerve) an indication for the use of regional anaesthesia. A regional nerve block can safely be performed on paediatric patients with respiratory distress, provided that the needle insertion, as well as the surgical site, is easily accessible. In certain cases, regional anaesthesia can be performed under mild general anaesthesia, after the patient has been intubated. In these situations, peripheral nerve blocks may be more preferable than central blocks. The advantages of combining both regional and general anaesthesia include reducing the requirements for intravenous and inhalational agents, thereby decreasing the risk of complications and also decreasing the recovery time. The patient should be extubated only when fully conscious and with the effect of anaesthetic inhalant worn off. This will allow the anaesthesiologist to effectively avoid aspiration (Saint-Maurice, 1995).

1.3.1.2 Disorders of the central nervous system

This is often considered to be a contraindication for performing regional nerve blocks. It is however more likely that an anaesthesiologist would refrain from performing regional nerve blocks on these patients more from the fact that there is a concern that the regional nerve block might worsen the disease state. The only true contraindications for performing regional nerve blocks on these patients are mechanical (neuropathy) and infectious conditions (infections in the vicinity of the block). Nevertheless, all children with disorders of the central nervous system should undergo careful evaluation before performing any regional nerve block on them. A neurologist should preferably do the evaluation and, as always, the risk *versus* benefit ratio should be carefully examined. (Saint-Maurice 1995)

1.3.1.3 Myopathy and myasthenia

Regional anaesthesia is especially indicated for patients with muscular dystrophy because it avoids the complications associated with general anaesthesia, particularly malignant hyperthermia. Unfortunately, due to the various anatomical deformities often found in these patients, certain regional nerve blocks might be more difficult to perform (Saint-Maurice 1995).

1.3.2 General contraindications or limitations of regional anaesthesia

Regional anaesthesia has a very important place in children. Like any technique, it has its distinct advantages and specific indications. However, it also has limitations, disadvantages and contraindications that should be taken into account when performing regional blocks. Although contraindications are block dependant and should be known before attempting any regional nerve block, general contraindications for regional anaesthesia include:

1.3.2.1 Patient refusal

Patient refusal is an absolute contraindication to regional anaesthesia. Appropriate information should be given to the patient regarding the technique, its advantages, disadvantages and potential complications. Informed consent must be obtained (Eledjam *et al.*, 200).

1.3.2.2 Local infections at the needle insertion site

Skin infections at the needle insertion site are an absolute contraindication to regional anaesthesia (Ecoffey & McIlvaine, 1991). This is also true for inflammation of the lymph nodes near the site of needle insertion.

1.3.2.3 Septicaemia (presence of pathogens in the blood)

1.3.2.4 Coagulation disorders

Coagulation disorders, as well as patients who are undergoing antithrombotic or anticoagulant treatment are contraindications to a regional block because of the potential risk of haematoma formation (Dalens, 1995; Ecoffey & McIlvaine, 1991). Most of the complications have been described with epidural anaesthesia due to multiple traumatic vascular punctures and needle placement difficulties (Dalens, 1995).

1.3.2.5 Neurological diseases involving the peripheral nerves (neuropathy)

Although neuropathy (due to neurological or metabolic diseases) is not an absolute contraindication to perform a regional block, a clear benefit over general anaesthesia should be made (Ecoffey & McIlvaine, 1991).

1.3.2.6 Allergy to the local anaesthetic solution

Less then 1% of all adverse reactions to local anaesthetics are due to patient allergy to the solution (Ramamurthi & Krane, 2007). Ester-linked local anaesthetics which are metabolized to para-amino benzoic acid (PABA) are far more likely to be associated with allergic reactions compared to amide local anaesthetics. Allergic reactions with amide local anaesthetics have yet to be reported in medical literature, although preservatives like methylparaben, present in many commercial preparations of amide local anaesthetics, are responsible for occasional allergic reactions (Naguib *et al.*, 1998). Ester local anaesthetic allergies are true anaphylactic IgE-mediated allergies and not anaphylactoid reactions more commonly associated with other drugs used in the practice of anaesthesia (Ramamurthi & Krane, 2007).

1.3.2.7 Lack of training

Adequate skills regarding a specific technique are essential for a successful procedure to avoid complications and malpractice claims. Skills and expertise are key points to success in regional anaesthesia (Eledjam *et al.*, 2000).

1.4) Equipment used for paediatric regional anaesthesia

The importance of selecting the appropriate devices and have them readily available when performing a regional block in children has long been underestimated and virtually all types of needles have been used for almost all types of block procedures (Dalens, 1999). Specifically designed needles and catheters are currently available for paediatric regional anaesthesia and it is now well established that a significant proportion of complications are directly related to the use of the wrong device (Giaufre *et al.*, 1996). The importance of the correct equipment for a successful block was further confirmed in a survey of South African paediatric anaesthesia (van Schoor, 2004).

Dalens (1999) stated that in addition to skin preparation solutions and sterile drapes to protect the site of puncture from bacterial contamination, the materials required to perform local or regional anaesthesia are rather simple but, nevertheless, specific. Sterile needles specifically designed to perform the relevant technique have to be used in children. He summarised the relevant equipment in a table (see Appendix A).

An intravenous cannula should always be inserted in either the upper or lower limb in case of local anaesthetic toxicity caused by an accidental intravenous injection, or profound sympathetic blockade from a high epidural block. Light general anaesthesia is normally given to the paediatric patient. The procedure must be carried out with a strict aseptic technique. The skin should be thoroughly prepared and sterile gloves must be worn as infection in the caudal space is extremely serious (Jankovic & Wells, 2001).

1.5) Imaging techniques used to aid in regional anaesthesia

1.5.1 Nerve stimulators and regional anaesthesia

The idea of stimulating a motor nerve in order to determine the ideal injection site for regional anaesthesia was first suggested by Von Perthes in 1912. Although, only within the past twenty years, have peripheral nerve stimulators (see Figure 1.1) become popular as clinical and teaching tools in regional anaesthesia practice (Visan *et al.*, 2002). Nerve stimulators enable confirmation of the correct needle placement without inducing paraesthesia (Vloka *et al.*, 1999) and, in turn, allow anaesthesiologists to perform the block in sedated or anaesthetised patients (Brown, 1993).

Figure 1.1: Some commercially available peripheral nerve stimulators (Vloka *et al.*, 1999).

Since Pither *et al.* (1985) made recommendations on the use of nerve stimulators in regional anaesthesia; there has been an explosion of new and varied nerve stimulators available on the market. Although the advances in the technology surrounding nerve stimulators have made their use to localise the desired nerve(s) much easier, the wide variety of functions and features can be confusing for first-time users. This could in turn leave anaesthesiologists with an insufficient understanding of the basic principles behind nerve stimulation.

1.5.1.1 Basic principles of nerve stimulation

Nerve stimulation techniques rely on the elicitation of appropriate motor responses to electrical current to confirm the proximity of the needle or catheter to the target nerve structure. Typically, nerve stimulation involves application of electrical current once the needle/catheter has penetrated the subcutaneous tissue, although surface mapping by transcutaneous electrical stimulation of peripheral nerves in children has been described (Bosenberg *et al.*, 2002).

The relationship between the strength and duration of the current and the polarity of the stimulus is of particular importance to nerve stimulation (Pither *et al.*, 1985). To propagate a nerve impulse, a certain threshold level of stimulus must be applied to the nerve. Below this threshold, no impulse is propagated. Any increase of the stimulus above this threshold results in a corresponding increase in the intensity of the impulse (Tsui, 2007).

It is also possible to estimate needle-to-nerve distance by using a stimulus of known intensity and pulse duration. A clear motor response achieved at 0.2 to 0.5 mA indicates an appropriate needle-to-nerve relationship. The tip of the needle is therefore close enough to the desired nerve to cause an effective block if the anaesthetic solution is administered. Nerve stimulation at <0.1 mA may indicate intraneural placement of the needle. This should be avoided as it may lead to nerve injury if the local anaesthetic is injected (Visan *et al.*, 2002).

Another important aspect to remember is that the cathode can be up to four times more effective at nerve depolarization than the anode, and thus it is the preferred stimulating electrode. Some problems may arise when nerve stimulators are not made to connect properly for other manufacturers' stimulating needles and an adapter would therefore be required. It is best to use similarly manufactured stimulators and needles if possible (Tsui, 2007).

A surface electrode is required to complete the electrical circuit and the optimal position to place the electrode on the patient's body during peripheral nerve blocks is controversial (Tsui, 2007). According to Hadzic and co-workers (2004), this is less critical than was previously thought due to the introduction of constant-current nerve stimulators.

1.5.1.2 Essential features of nerve stimulators

According to Visan *et al.* (2002), the essential features of the nerve stimulator include:

- *Constant current output:* This assures automatic compensation for changes in tissue or connection impedance during nerve stimulation, in turn, assuring accurate delivery of the specified.

- *Current display:* The ability to read the current being delivered is of utmost importance because the current intensity at which the nerve is stimulated gives the operator an approximation of the needle-to-nerve distance.
- *Current intensity control:* Current can be controlled using either digital means or an analogue dial. Alternatively, current intensity can be controlled using a remote controller, such as a foot pedal, which allows a single operator to perform the procedure and control the current output (Hadzig & Vloka, 1996)
- *Short pulse width:* Many peripheral nerve stimulators lack the ability for the user to control pulse width.
- *Stimulating frequency:* Nerve stimulators with a 1 Hertz (Hz) stimulation frequency (1 pulse per second) are the norm. A model with a 2 Hz stimulation frequency may prove to be more clinically advantageous because it allows faster manipulation of the needle.
- *Malfunction indicator:* This is a necessary feature because the operator should know when the stimulus is not being delivered because of malfunctions such as poor electrical connection and/or battery failure.

A study conducted by Bosenberg (1995) revealed that a relatively cheap, unsheathed needle could be successfully used to locate peripheral nerves with the aid of a nerve stimulator in anaesthetised children. Although a slightly larger current is required to produce a motor response when compared to sheathed needles, a success rate of greater than 98% underlines its value as a cost-effective teaching tool, and the ease with which a technique can be mastered when using a nerve stimulator.

Surface nerve mapping or transdermal nerve stimulation is a modification of the standard nerve stimulator technique and can be used to trace the path of a nerve prior to skin penetration. Surface nerve mapping could prove to be most useful in paediatric patients since anatomical landmarks are less precisely defined (Bosenberg *et al.*, 2002), and paediatric patients are at the greatest risk for complications of regional anaesthesia.

(Giaufre *et al.*, 1996) Nerve mapping offers a further dimension for localisation of superficial peripheral nerves prior to skin penetration in both infants and children (Bosenberg *et al.*, 2002).

For locating superficial nerves, in patients of normal weight or paediatric patients, a special device can be used together with the nerve stimulator to trigger a transdermal response from the target muscle. The pulse duration of the device is set to 1 millisecond (ms) and the current range to 5 mA. In this way, it is possible to get a better fix on the puncture site or even correct the puncture direction. This also serves as an invaluable training tool for anaesthesiologists. Not only can the correct stimulus response be demonstrated but needle localisation and direction can be practiced before the needle is inserted (www.nerveblocks.net, 2009)

Bosenberg and co-workers (2002) stated that peripheral nerve stimulation should not be a substitute for sound anatomical knowledge and careful technique. In a study, they did however show that using a nerve stimulator does provide a greater degree of reliability and accuracy in finding the correct needle insertion site, compared to using only anatomical landmarks or paraesthesias to perform nerve blocks. It is also a safer technique for attaining close proximity to the actual nerve.

A combination of using a nerve stimulator/surface nerve mapping device and anatomical landmarks seem to be the best method for accurate, safe and successful blockade (Bosenberg, 1995).

1.5.2 Ultrasound guidance and regional anaesthesia

1.5.2.1 Advantages of ultrasound guidance during regional anaesthesia

The use of ultrasound guided techniques for performing regional anaesthesia has greatly increased within the past decade. Recent studies show that ultrasound guided nerve blocks may have many advantages over traditional techniques. These studies reported less vascular puncture, higher success rates, and a reduced dose of local anaesthetic required in order to obtain a successful block (Marhofer *et al.*, 2004; Sandhu *et al.,* 2004; Bigeleisen, 2007).

1.5.2.2 Basic principles of ultrasound

Ultrasound machines can typically deliver sound waves of 2–15 MHz. Characteristically, the higher the frequency, the less the penetration depth but the better the resolution and *vice versa*. In the paediatric population, a high frequency linear probe is usually sufficient as the anatomy is much smaller and most structures being blocked are reasonably superficial. Sound waves propagate through the body and the amplitude of the reflected signals is based on different acoustic impedance of human tissue and fluids. Signals of least intensity appear dark (hypoechoic) or black as with body fluids, while signals of greatest intensity appear white (hyperechoic) as with bones and with intermediate intensities appearing as shades of gray. A common artefact is anisotropy, which is caused by an incidence angle of less than 90^{o} between the probe and the structure being imaged. This results in poor or no reflection of the ultrasound beam from the tissue and, consequently, an inability to visualise it. The ultrasound beam must be oriented perpendicularly on the nerve axis to be able to visualise it (Marhofer *et al.* 2005; Brain *et al.*, 2007).

1.5.2.3 Ultrasound guided regional anaesthesia:

The success of ultrasound guided nerve blocks relies on several aspects (Perlas & Chan, 2008):

- *Quality of image:* This depends on the quality of the ultrasound machine and transducers, proper transducer selection (e.g., frequency) for each nerve location, sonographic anatomy knowledge pertinent to the block, and good hand-eye coordination to track needle movement during advancement.

- *Patient position and technique:* Optimal patient positioning and sterile technique is essential. This is particularly important for the continuous catheter technique when it is necessary to use sterile conducting gel and a sterile plastic sheath to fully cover the entire transducer.
- *Nerve stimulation:* Nerve localisation by ultrasound can be combined with nerve stimulation. Both tools are valuable and complementary and not mutually exclusive. Ultrasonography provides anatomical information, while a motor response to nerve stimulation provides functional information about the nerve in question.
- *Spread of anaesthetic solution:* Ultrasound allows the anaesthesiologist to observe the spread of the local anaesthetic solution as well as real-time visual guidance to navigate the needle toward the target nerve.

Two approaches are generally available to block peripheral nerves. The first approach aims to align and move the block needle inline with the long axis of the ultrasound transducer, so that the needle stays within the path of the ultrasound beam (see Figure 1.2a). In this manner, the needle shaft and tip can be clearly visualized. This approach is preferred when it is important to track the needle tip at all times (e.g., during a supraclavicular block to minimize inadvertent pleural puncture). The second approach places the needle perpendicular to the probe (see Figure 1.2b). In this case, the ultrasound image captures a transverse view of the needle, which is visible as a hyperechoic "dot" on the screen. Accurate moment-to-moment tracking of the needle tip location can be difficult, and needle tip position is often inferred indirectly by tissue movement. This approach is particularly useful for continuous catheter placement along the long axis of the nerve.

(a) **(b)**

Figure 1.2: (a) Probe and needle alignment during performance of an interscalene block.

Note the relative position of the needle in line with the probe, which allows visualisation of the entire needle trajectory (Perlas & Chan, 2008).

Figure 1.2: (b) Probe and needle alignment during performance of a subgluteal sciatic nerve block.

Note the relative position of the needle perpendicular, or "out of plane" with the probe (Perlas & Chan, 2008).

1.5.2.4 Ultrasound in children

Most nerve blocks can be performed on children using 5 to 10MHz linear ultrasound transducers. In addition, small probes are required due to the narrow anatomical relationships in children. "Hockey-stick" probes, with a surface length of 25mm, are particularly well suited for this purpose. Also, higher-frequency transducers are available for portable ultrasound units. Theoretically, superficial nerve structures can be better visualised using these higher frequencies. Lower frequencies (2 to 4MHz) are preferable for deeper blocks, such as psoas compartment blocks in larger children (Kim, 2009).

1.5.3 Magnetic Resonance (MR) Imaging

Imaging of peripheral nerves have, for many years, been limited by the small size of the nerves as well as the difficulty in distinguishing neural structures from the surrounding soft tissue, especially in paediatric patients. MR imaging has, due to recent advances in the technology, become the method of choice for visualisation of peripheral nerves (Birchansky & Altman, 2000). Although this can not be done while the block is being performed (as with ultrasound), it appears to be ideal to study the position of the peripheral nerves and associated landmarks for any potential anatomical abnormalities. However, the availability and high cost of MR imaging remains a limiting factor for most hospitals, especially in developing countries. In addition, specialised non ferro-magnetic needles would be required to place the block.

1.6) A survey into paediatric regional anaesthesia in South Africa: Clinical anatomy competence, pitfalls & complications

Precise information on epidemiology and morbidity of paediatric regional anaesthesia, especially from a clinical anatomy perspective, is scarce. A survey was therefore conducted amongst anaesthesiologists working in both private and government hospitals (n=80). This survey aimed to (a) determine, through means of a questionnaire, the scope of regional anaesthetic techniques performed on paediatric patients in South Africa, (b) determine the competence of anaesthesiologists to perform these procedures based on their clinical anatomy knowledge regarding each nerve block; and (c) select five problem procedures based on the anatomical competence that anaesthesiologists display when performing each nerve block (van Schoor, 2004).

A list of 18 regional anaesthetic procedures common in paediatric practice was compiled and a detailed questionnaire (see Appendix B) was completed by a randomly selected sample of anaesthesiologists. The problem procedures chosen were based on those that were performed most often, ranked important, encountered most difficulties and complications, where anaesthesiologists felt uncomfortable performing the procedures and where the influence of clinical anatomy knowledge on the safe and successful performance of the procedure was ranked highest.

This survey addressed the need for better understanding of the anatomy behind regional nerve blocks in paediatric patients as well as realising the importance of a sound anatomical knowledge base that acts as the foundation on which successful clinical procedures, such as regional nerve blocks, rest. The survey also aimed to gain a better understanding of paediatric regional anaesthesia in South Africa and serve as a basis on which regional nerve blocks could be taught in residency programs.

Anatomy knowledge contributes greatly to the success of any clinical procedure. It also increases the comfort levels of the anaesthesiologist performing the procedure, which in turn will decrease the occurrence of complications. There is a substantial “hiatus” in the precise clinical anatomy knowledge of the paediatric population. Standard paediatric practice is to take the normal anatomy of adults and then extrapolate the data to paediatric patients.

Using the data obtained from the survey, five problem regional anaesthetic procedures performed regularly on paediatric patients were identified (see Appendix C). These procedures were (1) the caudal epidural block; (2) lumbar epidural block; (3) the axillary approach to the brachial plexus; (4) the femoral nerve block; and (5) the ilio-inguinal/iliohypogastric nerve block. After conducting an intensive literature review regarding the above, a series of anatomical pitfalls for each procedure that could have contributed to the occurrence of complications during the performance of each, was identified.

The axillary approach to the brachial plexus was abandoned because the clinical situation could not be replicated. The pulse of the axillary artery is obviously absent in cadavers. Therefore, in order to validate the subsequent anatomical studies it was decided to use the infraclavicular approach instead.

Recent studies have shown this technique, although not popular, to be as safe and effective as the axillary approach with the same, if not more, indications for surgery of the upper extremities in paediatric patients (Dalens, 1995; Kapral *et al.*, 1996; Wilson *et al.*, 1998; Borgeat *et al.*, 2001). Recent modifications made to the original technique described by Raj and co-workers (1973) have also eliminated many of the complications, such as pneumothorax, which made anaesthesiologists wary of performing the procedure on paediatric patients (Kapral *et al.*, 1996; Wilson *et al.*, 1998; Borgeat *et al.*, 2001).

This thesis focuses on these five procedures and attempts to highlight the anatomical pitfalls identified in the survey. In addition this dissertation compares data obtained from anatomical dissections performed on neonates in our laboratory with those published and with those obtained from adult dissections.