Conus Medullaris Termination Study: 
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Conus Medullaris Termination Study: A Retrospective Magnetic Resonance Imaging Study to Determine if Spinal Anesthesia is Safe in the L2-L3 Interspace.

1. Miller says 10% of Spinal Cords End at L3
2. But this was based on a cadaver study
3. So How Many Spinal cords do end below L2?

Is it safe to do spinal anesthesia at the L2-L3 interspace?
Inves@gators

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Introduction: Background:
Spinal Injury
Landmarking
Tuffier’s Line
CMT Location
The L2-L3 interspace has generally been accepted as safe for neuraxial anesthesia and is common practice today.

Over the last two decades there have been multiple reports of spinal cord injury following spinal anesthesia.

It is possible that injury may be due to the fact that the (CMT) can extend as low as the upper third of the L3 vertebrae and may put the spinal cord at risk.
Many studies show that landmarking to a specific interspace is difficult and we are accurate only 29-41% of the time.\textsuperscript{15-19}

When landmarking using iliac crests it has been found that anesthesiologist’s are one interspace higher over half of the time and can be up to four interspaces off.\textsuperscript{15}

This is a problem in spinal anesthesia because spinal needles could potentially enter the L1-L2 interspace or even higher unintentionally into the spinal cord and cause spinal cord damage.

With the known difficulties in landmarking, it is therefore important to find out the percentage of spinal cords that are terminating in the L2-L3 interspace, and even the L1-L2 interspace, since it has been shown that we can be unintentionally higher than intended with spinal anesthesia.
Introduction: Background: Tuffier’s Line

• Tuffier’s Line is a horizontal line which intersects both iliac crests.

• In a study by Kim et al Tuffier’s Line was found to be radiologically located between L4 and L5.

• Another study revealed that the palpated Tuffier’s Line falls at the L3-4 interspace, one interspace higher than its radiological location.

• This difference may lead to selection of a higher interspace for neuraxial technique and put the patient’s spinal cord at risk of injury.

• As a result of this, it is important to assess exactly where Tuffier’s Line is located radiologically in both normal patients and those with spinal pathology.
Introduction: Background: CMT Location

- Previous studies have reported the range of the CMT from T12 to L3, but it is widely accepted to terminate at the level of L1.\(^\text{21-24}\)

- There are MRI and cadaver studies reported in the literature. However, the cadaver studies tend to show the CMT level at L2.\(^\text{25-27}\), which is lower than most of the MRI studies at L1.\(^\text{14,21-24,28-32}\)

- However one study discusses the limitations of cadaveric studies since the spinal cord increases in mass after the embalming process and this may affect results.\(^\text{33}\)
Primary and Secondary Objectives

Primary:

• To determine the location of the conus medullaris termination in an adult and pediatric population and what percentage of individuals terminate below the L2 body

• This primary objective was chosen in order to determine if spinal anesthesia is safe at the L2-L3 interspace
Primary and Secondary Objectives

Secondary:

• A secondary objective is to determine the relationship of CMT to age, gender, BMI, and spine pathology.

  • Spine pathology includes; disc degeneration, bone degeneration, compression fractures, osteoarthritis, osteoporosis, tumor, spinal stenosis, scoliosis, spondylolisthesis, spina bifida or other congenital abnormality

  • We are also looking at Tuffier’s Line and the percentage located above the L4 body, along with its relationship to age, gender, BMI or any spine pathology.

  • With this information we can estimate what percentage of patients are at increased risk of spinal cord injury during neuraxial technique as well as specific groups that may be at increased risk.
Study Design

Type:
- Retrospective case control study carried out at Hamilton Health Sciences, Hamilton, Ontario, Canada

Population:
- Pediatric and adults patients, no age restrictions, male and female
Study Design

Inclusion Criteria:

- Pediatric and adult patients no age restrictions
- Male and female
- With a lumbo-sacral MRI completed and reported by radiologist
- We plan to include abnormal MRI scans and will categorize them according to the type of abnormality
Exclusion Criteria:

• Any patients who did not have an axial lumbar MRI will be excluded due to difficulties with definitively identifying the conus medullaris termination

• Any patients who are identified as having sacralization or lumbarization will also be excluded due to difficulties with counting vertebra and hence assigning a CMT level.
Study Design

Duration and Start:

- The start date for data collection will begin in Nov 2013 for Lumbar MRI’s completed between September 2012 to September 2013.

- Lumbar or abdominal x-rays obtained within 5 years of the MRI will also be collected.

- The research protocol has been submitted to the Research Ethics Board (REB) in October 2013 and awaiting approval.
Methodology

Data Collection/Management:

• Lumbar MRI’s, lumbar x-rays, abdominal x-rays and spinal history from Meditech will be collected

• Data will be collected by Dr.’s Lisa Udovic, Kathleen Oman, Thomas Kim, and Leora Bernstein

• It will be collected by a sequential series on scans done between September 2012 to September 2013 to prevent selection bias

• Redcap, an online data collection tool will be used for the collection and storage of data and saved on a password protected computer
Methodology

Data Collection/Management:

• The MRI scans will be assessed by two reviewers from the radiology department, Dr. Nina Singh and Dr. Luigi Matteliano

• They will determine the level of the CMT and Tuffier’s line and any discrepancies will be resolved by consensus

• The vertebral bodies will be divided into thirds, upper, middle and lower third. The CMT level will either be assigned to the appropriate 1/3 of the vertebral body or the interspace between.
Data Collection/Management:

- We will also be reviewing Tuffier’s line on the MRI and lumbar x-ray if available and determine if it corresponds to L4/L5. This will include the body of both L4 and L5 vertebrae and the space in between. We want to determine the percentage occurring above the L4 body.
Methodology

Proposed Data Collection Fields:

- MRN
- Initials
- Gender
- Age
- Ethnicity
- Height
- Weight
- BMI
- Spine History
- Indication for Lumbar MRI
- Lumbar MRI Normal
- Type of Pathology on Lumbar MRI
- Level of CMT
- Is CMT level at or below L2
- Tuffier’s Line level on MRI
- Lumbar x-ray done?
- Indication for lumbar x-ray?
- Lumbar x-ray normal?
- Pathology on Lumbar x-ray?
- Tuffier’s Line level on Lumbar x-ray
- Abdominal x-ray done?
- Indication for abdominal x-ray?
- Abdominal x-ray normal?
- Pathology on Abdominal x-ray?
- Tuffier’s Line level on Abdominal x-ray?
- Is Tuffier’s Line between L4 and L5?
- Is Tuffier’s Line above L4?
REB Approval:

• We have applied for approval by the local Research Ethics Board (REB) in October 2013.

• The information collected will be kept confidential and anonymous.

• Data will be stored in Redcap on password protected computers in the research department at McMaster University and any data on USB key will be encrypted.
• We calculated a sample size of **1000** subjects based on an estimated incidence of 2.5% for a CMT occurring below L2 and a margin of error of 1%.

• We will describe the number of patients whose conus terminates below the body of L2 with a percentage and 95% confidence interval

• We also plan to look at what percentage of the population’s iliac crest corresponds to L4-L5 interspace

• The CMT will be reported as a mean/median with differences between age groups and sex with an analysis of variance.

• The impact of demographics (age, gender, ethnicity and BMI) and clinical (spine diagnosis type) will be evaluated using logistic regression analysis. Significance will be assumed at p=0.05 or less.
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Margin of Error ME
Limitations:

The first limitation is that the study is retrospective in nature.

The patients also have an indication for an MRI and therefore the results may not be applicable to the general population.

Another concern is that according to radiology it may be difficult to accurately use the MRI to estimate Tuffier’s Line if the MRI doesn’t contain the entire iliac crest.

Other studies have addressed this problem by performing secondary studies looking at x-ray correspondence to MRI derived Tuffier’s Line.
Questions, Comments or Suggestions?
References


6. Hamandi, K, Mottershead J, Lewis T. Irreversible damage to the spinal cord following spinal anesthesia Irreversible damage to the spinal cord following spinal anesthesia. Neurology 2002; 59: 624–626.
References


References


References


References


References


34. Miller RD. Miller’s Anesthesia. 7th Edition. Churchill Livingstone 2010; Chp. 51