8-2009

Treatment Effectiveness for Resolving Post Dural Puncture Headache

Tim Overend

Treatment Effectiveness for Resolving Post Dural Puncture Headache

by

Tim Overend

Bachelor of Science in Nursing, University of North Dakota, 1998

An Independent Study

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota
August
2009

TABLE OF CONTENTS

LIST OF TABLES

Table

Page

ABSTRACT

Postdural puncture headaches are a complication associated with neuraxial anesthesia. The risk of developing a postdural puncture headache varies among the patient population in which neuraxial anesthesia is utilized, as well as the experience of the anesthesia provider inserting the neuraxial block. Several options exist regarding treatment for PDPH's, and the knowledge, as well as the skill level of the provider, plays an important role in the best utilization of the treatment options. The purpose of this independent project was to explore the treatment options that are available for both the provider and the patient, incorporating available technology in assisting the provider with treatment options.

A comprehensive literature review, including case reports and prospective studies, was conducted. The findings were compiled and presented in a power point format which included the etiology of PDPH as well as the association between treatment modalities and resolution of PDPH's. The physiologic framework of adaptation and homeostasis was used as the theoretical framework for this study. The power point findings were presented at the North Dakota Association of Nurse Anesthetists Spring Educational Meeting and to first year nurse anesthetist students at the University of North Dakota, Grand Forks, North Dakota.

CHAPTER I

INTRODUCTION

Post Dural Puncture Headache (PDPH) is a phenomenon caused by the leaking of cerebral spinal fluid (CSF) through an intentional or non-intentional hole in the dural and subdural membrane created by administration of spinal or intrathecal injections, or inadvertently created by epidural injections with accidental puncture of the dural and subdural membranes (Porth, 2005). Depending upon the size of the epidural needle studies have shown a rate of inadvertent dural puncture in 20% of the epidural anesthesia cases reported (Turnbull & Shepherd, 2003). An incidence rate of PDPH is noted as high as 75% in patients following accidental dural puncture with 16-18 gauge epidural needles (Ayad, Demian, Narouze, & Tetzlaff, 2003). These headaches are primarily postural in nature and can be debilitating, leaving the patient incapacitated for periods of up to two weeks if they are not treated.

Clinical Problem

According to O'Connor, Gingrich, & Moffat (2007), PDPHs may occur with as small a loss as 20 ml of CSF following regional anesthesia. Post dural puncture headaches (PDPH) may occur immediately following puncture of the dura or onset may be delayed by as much as three days. Average duration of these headaches is 7-14 days, with a documented exception of up to 1 year. Most often the symptoms of these headaches resolve with lying down or after a 7-14 day period they resolve spontaneously (Mikhail, Morgan and Murray, 2006). For the patient in the upright position symptoms

are noted almost immediately and include: a) bilateral frontal and occipital headache, b) nausea, c) vomiting, d) visual disturbances, and e) hearing alteration (Gaiser, 2007).

Patients who are suffering from PDPH may or may not understand the etiology of their headache. Healthcare providers need to recognize the signs and symptoms of PDPH and be able to provide education and information to their patients regarding the cause of the headache and the options available related to the treatment of their headaches. Healthcare providers need to understand the physiology of PDPHs, symptoms of PDPH, treatment options available with respect to when the onset of symptoms occurred, and the complications associated with treatment modalities. As patients today are better educated regarding health care, they need to be given options and rationales for treatment and allowed to make decisions regarding their own care.

There are several methods of treatment available for patients suffering from PDPH. These treatments range from conservative to invasive. Health care providers need to be able to provide adequate information to patients in order to allow them to make educated decisions regarding their treatment.

Purpose of the Independent Study

The purpose of this study is to determine the efficacy rates of the various treatments available and to provide a power point presentation to Student Registered Nurse Anesthetists (SRNAs) and Certified Registered Nurse Anesthetists (CRNA) at both a state Nurse Anesthetist meeting and in the classroom for the SRNAs. This information will allow them to better guide their case management and provide teaching to patients who have been affected by PDPH.

Conceptual Framework

This project is based on a physiological framework. Due to the physiological nature of PDPHs, concepts of CSF pressures and volumes will be discussed. Problems associated with loss of CSF account for the PDPH. An understanding of the treatment options will allow healthcare workers and patients to make educated decisions regarding care and treatments available for PDPH patients. Certain treatment options are time sensitive and these issues will be addressed as well.

Physiology of PDPH

CSF is produced in the ventricles of the brain by the filtration of blood in the choroid plexuses. The production of CSF occurs at a rate of 0.35 ml/min, or at a rate of 21 ml/hour or 500 ml/day. Total circulating volume is approximately 150 ml. (Turnbull & Shepherd, 2003). Excess CSF enters the subarachnoid space and circulates around the brain and spinal cord before being absorbed by arachnoid granulations on the cerebral hemispheres and then to the cerebral venous sinuses (Homer, 2002). The purpose of the fluid is to bathe and surround the brain with a protective cushion (Levine & Rapalino, 2001). PDPH is thought to result from the loss of CSF through the dural tear or puncture into the epidural space (Gaiser, R. 2007). With the loss of CSF, there is a decrease in CSF pressure. It is believed that PDPH is a result of traction on pain-sensitive structures within the cranial cavity (Levine & Rapalino, 2001).

A second theory for the cause of PDPH is cerebral venous dilation. As a result of the loss of CSF, there is a decrease in CSF pressure, yet the intravenous pressure remains the same. This difference in pressure results in dilation of these veins (Gaiser, 2007).

According to Sudlow and Warlow (2001), it is believed that the loss of CSF and the resultant traction causes pain sensations from the meninges, intracranial veins, and the

cranial nerves. With the loss of CSF, patients experience severe headaches that are postural in nature. These headaches are worse in the upright position, and resolve within 30 minutes of lying down. The severity of the headache may be dependent upon the volume of the CSF that was lost. Women are more prone to PDPH then men.

Lybecker (1995) and Vandam and Dripps (1995) noted visual disturbances which occurred in 14% of the patients that they studied with PDPHs. The visual disturbances are thought to be caused by transient paralysis and dysfunction of the cranial nerves III and IV. Due to its long intracranial course the abducens or cranial nerve VI is most frequently affected. Abducens palsy normally occurs 4-14 days after the dural puncture and normally resolves completely after 1 to 4 months.

Approximately 10% of patients who suffer from PDPH also experience alteration in the low frequency range of hearing. The loss of CSF decreases intracranial pressure, which results in decreased pressure transmitted through the cochlear aqueduct. The decreased pressure then disrupts the normal positioning of the hair cells in the inner ear, resulting in hearing impairment for these patients (Gaiser, 2006).

Definitions

For the purposes of this study, the following definitions were used:

Blood patch: Injection of 15-20 ml of the patient's own blood into the epidural space at the site of the previous puncture or one level below.

Epidural: The introduction of a local anesthetic, with or without an opioid, infiltrated into the epidural space surrounding the dura mater at the lumbar or thoracic vertebral levels which induces sensory and/or motor blockade of the nerve roots and the spinal column, resulting in an operative anesthesia state.

Neuraxial anesthesia: Spinal or epidural anesthesia.

Spinal block: The injection of local anesthetics or narcotics into the subarachnoid space.

Post dural puncture headache (PDPH): A headache that results from the breach of the dura mater and results in a CSF hypotensive headache.

Wet tap: A situation when the epidural needle passes through the epidural space and inadvertently enters the subarachnoid space causing a leak of CSF.

Significance of the Clinical Problem

The clinical problems associated with PDPH are variable. Through extensive research it has been noted that the incidence rate of PDPH may be as high as 80% for patients who experienced an inadvertent dural puncture during epidural anesthesia. Factors contributing to the incidence of PDPH include the age of the patient, gender, and the experience level of the practitioner administering the epidural. The likelihood of developing a PDPH decreases as age increases. Additionally, women are more likely to experience PDPH than men. The more experienced practitioner has a decreased likelihood of inadvertent dural puncture and creation of a PDPH. Poor body habitus, such as obesity, may play a role in the likelihood of developing a PDPH.

Patients who experience PDPH may suffer from symptoms, on average, 7-14 days after the inadvertent puncture. These symptoms may include a bilateral headache that develops within 7 – 14 days after lumbar puncture. The headache worsens within 15 minutes of assuming the upright position and patients often experience generalized pressure or a throbbing sensation in the bilateral frontal and occipital regions, radiating through the neck and shoulders. The headache worsens with movement such as sneezing or coughing. Blurred vision and tinnitus often accompany these headaches. The symptoms will improve within 30 minutes if the patient returns to the supine position.

Most headaches will disappear or improve within 30 min of resuming the recumbent position, or resolve entirely within a 7-14 day period (Evans, Armon, Frohman, and Goodin, 2000).

Treatment options for PDPHs include conservative treatments with fluid hydration and oral pain medications, or invasive treatments such as a saline patch or a blood patch. For those who choose a blood patch, a success rate of 95% is noted for the resolution of the headaches, and subsequent patches may be administered if the first blood patch was unsuccessful. Complications of blood patches are similar to those for neuraxial anesthesia and may include creation of another dural tear with subsequent PDPH formation and risk of infection.

Assumptions

The following assumptions were made for this study:

1. The healthcare providers, CRNAs and SRNAs, who receive this information, will be interested in the material presented.
2. There is a need for further information regarding alternative treatments or options such as ultrasound guided interventions
3. The readers of this paper will have advanced knowledge and understanding of the physiology of the spinal column, neuraxial anesthesia, and anesthesia equipment related to neuraxial anesthesia.
4. The research studies included in this paper were accurately reported and of clinical significance in regards to the study findings.

Limitations

The project was limited to utilization of case studies and prospective studies. Patient and clinician differentiation between migraine headache and PDPH also creates a potential limitation in the research regarding PDPH.

Summary

PDPHs result from the loss of CSF through a tear in the dura mater. This tear may be due to an inadvertent dural puncture while attempting to administer epidural anesthesia with large bore needles. PDPHs may be very uncomfortable and debilitating, forcing a patient to remain in the supine position for a period of 7-14 days until the headache resolves spontaneously. Treatment options are available for patients with PDPHs, but these carry associated risks similar to neuraxial anesthesia. Patients and healthcare providers need to be aware of treatment options as well as the risks associated with these treatments in order to effectively manage a PDPH.

CHAPTER II

LITERATURE REVIEW

Introduction

This section presents literature that relates to PDPH and accepted treatment modalities to resolve the symptoms of PDPH. An online search during March 2008 included evidence from these databases: (a) Cochrane Central Register of Controlled Trials, (b) CINAHL, (c) MEDLINE/Pubmed, and (d) National Guideline Clearinghouse. The Mesh headings used for Pubmed and key words for all databases included: (a) anesthesia, (b) blood patch, and(c) postdural puncture headache. Only studies with the latest information pertaining to PDPH were analyzed and assessed. These studies addressed varying acceptable treatment methods and strategies that may be used to resolve pain, improve patient outcomes, and decrease headache time so that patients may return to normal activities of daily living. This review of PDPH's will be limited to adult patients who have had neuraxial anesthesia.

Review of Related Studies

The International Headache Society has defined a PDPH as a bilateral headache that develops within 7 days after lumbar puncture and disappears within 14 days after the lumbar puncture. The headache worsens within 15 minutes of assuming the upright position and disappears or improves within 30 min of resuming the recumbent position (Evans, Armon, Frohman, and Goodin, 2000).

Dr. August Bier was the first physician to describe PDPH in 1898. Dr. Bier attributed the onset of the headache to persistent leakage or loss of CSF, which results in

a drop in intracranial pressure. When the patient is in the upright position the pressure of CSF increases in the spinal canal and leads to an increased loss of CSF at the puncture site. This increased loss of CSF further drops intracranial pressures and creates CSF hypotension. Dr Bier's explanation is still accepted today, however further investigation has resulted in new findings. Currently, it is believed that when CSF is lost, the decreased CSF pressure results in traction of intracranial structures resulting in pain. This traction and pain are worse in the upright position. Activation of adenosine receptors, as a result of the loss of CSF, may then result in a compensatory increase in cerebral vessel dilation and an increase in blood flow. These increases will then result in a headache. Further investigation has shown that decreased cranio-spinal elasticity leads to rapid lowering of CSF pressure and intracranial venous dilation while in the upright position. This explains the orthostatic nature of the headaches (Lee, Sennett, & Erickson, 2007).

Incidence

Predisposing factors for PDPH include: (a) female gender, (b) ages between 18 and 30 years old, (c) low body mass index, (d) history of previous PDPH, (e) the use of large diameter spinal needles, (f) orienting the bevel of the epidural needle in horizontal plane, and (g) not reinserting the stylet. The use of small diameter needles with atraumatic tips and orienting the needle bevel in perpendicular plane, in order to spread the ligamentum flavum fibers rather than cut them, are recommended to reduce the risk of PDPH during spinal anesthesia (Hurtado &Clarkson., 2007).

In a study by Scavone, Wong, and Sullivan (2004), the authors found that nearly all PDPHs occur within 3 days after the puncture; however, some may have an onset as late as 12-14 days. Patients often experience generalized pressure or a throbbing sensation in the bilateral frontal and occipital regions, radiating through the neck and

shoulders. The headache worsens in the upright position and with movement such as sneezing or coughing. The symptoms will improve within 30 minutes if the patient returns to the supine position. Most headaches will resolve within a 7-14 day period. The dura mater heals and the CSF volumes and pressures return to normal. Some patients will experience relief in as little as 24 hours; however, some have reported headaches for as long as 6 to 12 months. Most adult studies have shown the incidence of PDPH following spinal anesthesia to be less than 20%, although these numbers are dependent upon the size of the needle used, and the type of procedure (Turnbull & Shepherd, 2003).

Kang, Goodnough, and Lee (1992) found an incidence rate of PDPH of 9.6% with the use of a 26-gauge Quincke spinal needle, and a 1.5% incidence rate with a 27-gauge Quincke needle. The decreased rate of incidence with the 27-gauge Quincke needle correlates with the reported incidence rate for pencil-point spinal needles. This correlation raises the question if a pencil-point needle is advantageous in decreasing the risk of PDPH. Santanen, Rautoma, & Luurila (2004), studied the incidence of PDPH for a 27-gauge Quincke (a cutting tipped needle) and Whitacre (a type of pencil-point) needle in 676 patients. The incidence of PDPH was found to be 2.7% in the Quincke group and 0.37% in the Whitacre group. It seems that PDPH is greatly reduced with a 27-gauge needle, but a pencil-point needle does reduce the incidence even further.

Sudlow & Warlow (2001) found that patients who suffer unintentional dural puncture during epidural anesthesia appear to be in a higher risk category due to the larger diameter (16-18 gauge) needles that are used for the placement of epidurals. These larger needles cause a larger defect when the dura is accidentally punctured. Additionally, parturients may have an increased loss of CSF due to the accompanying rise in intra-abdominal pressure associated with contractions during labor.

In a study performed by Ayad, Demian, Narouze, & Tetzlaff (2003), the authors reported a PDPH incidence rate as high as 75% in patients after accidental dural puncture with 16-18 gauge epidural needles. This study involved 115 patients over a 5 year period who had experienced unintentional dural puncture. This represents a 0.86% wet tap rate for those patients who received epidurals during the five year period. Patients who had previously experienced: (a) PDPH, (b) migraine headaches, (c) severe pre-eclampsia, and (d) those requiring a cesarean delivery were excluded from the study. A summary of the results are provided in Table 1.

Table 1. Incidence of PDPH (Ayad et al, 2003)

	Group A (n=37)		Group B (n=35)		Group C (n=31)		*P* Value	*P* Value
	N	%	N	%	N	%	A-B	B-C
PDPH	34	91.9%	18	51.4%	2	6.2%	.001	.0001
Mild headache	4	11.0%	7	11.0%	1	11.0%	NS	NS
Severe headache	30	81.1%	11	11.0%	1	11.0%	.01	.001
Blood patch	30	81.1%	11	11.0%	1	11.0%	.01	.001

The groups in this study were managed by three different protocols. Group A , originally n=37, were patients who experienced accidental dural puncture with an 18-gauge Tuohy needle on the first epidural attempt, and subsequently had a 20-gauge epidural catheter placed on the second attempt. This catheter was then removed immediately after delivery. Group B, originally n=35, experienced accidental dural puncture with an 18-gauge Tuohy needle on the first epidural attempt, with immediate placement of a 20-gauge continuous intrathecal catheter. This catheter was removed immediately after delivery. Group C (n = 31) experienced accidental dural puncture with an 18-gauge Tuohy needle on the first attempt, with immediate placement of a 20-gauge

continuous intrathecal catheter. The difference between groups B and C were that the catheter in group C was left in place for 24 hours after the delivery.

Significant p values of < 0.01 for all three groups indicate that there is a strong correlation between accidental dural puncture and PDPHs. This data also correlates with the use of large gauge epidural needles and subsequent PDPHs. The use of intrathecal catheters after accidental puncture indicates that both the severity and the duration of the PDPHs may be reduced. A large reduction is noted when the catheters are left in for a minimum of 24 hours. The decision to leave the catheters in may be guided by policy at different health care facilities.

Treatment Modalities

The treatment for PDPH ranges from conservative treatment to invasive treatment. The conservative methods may include strict bed rest, IV or oral hydration, and oral analgesics. Caffeine may be used IV or orally (Stoelting & Dierdorf, 2002). Caffeine causes cerebral vasoconstriction with no resulting increase in intracranial pressure. According to Yücel, Özyalçin, Talu, Yücel and Erdine (1999), IV administration of caffeine sodium benzoate has been utilized and has decreased the severity of the headaches but does not resolve the headaches.

Interventional techniques involve the injection of a variety of agents into the epidural space, thereby increasing intraspinal and intracranial pressures. Agents used include saline, dextrose, saline mix, and autologus blood patch (Hurtado & Clarkson 2007). Gormley was the first to use the blood patch technique in 1960. This technique involves an injection of 12-15 ml of autologus blood into the epidural space, as close as

possible to the previous epidural injection site and subsequent dural hole. Seven patients, including Gormley himself, were treated. Relief from the headaches was noted after 30 minutes in all 7 patients (Gormley, J.B., 1960).

Prophylactic use of saline injections and infusions after unintentional puncture of the dura has been used in an attempt to prevent PDPH. It has been noted that decreased incidence and severity has resulted from these injections/infusions. In a study of 241 patients who had unintentional dural punctures, it was noted that the incidence of PDPH was decreased from 86% to70% with the use of a crystalloid intravenous infusion for 24-36 hours. The use of one time injections of 40 to 60 ml of normal saline into the epidural space also showed a similar decrease in PDPH. In summary, the use of saline injections and infusions is poorly supported by a small sample size and poor results (Warwick & Neal, 2007).

Scavone, Wong, & Sullivan (2004) studied a group of 64 patients with accidental dural punctures with a 17 gauge epidural needle. These patients were randomized for either a blood patch or implied blood patch. Blood was drawn from all participants regardless of which study group they were randomly assigned. There was a difference noted in the rate of PDPH's or the need of a repeat blood patch after 24 hours in both groups of patients. Those who did receive the prophylactic blood patch did notice a shortened duration of PDPH. The author did question exposing these patients to the risk of a blood patch with a minimal improved outcome.

Evans, Armon, Frohman, & Goodin (2000) found that the placement of a subarachnoid catheter immediately after an accidental dural puncture may reduce the incidence of PDPH. Denny, Masters, Pearson, Read, Sihota, and Selander (1987) noted an incidence of PDPH < 1% when a continuous 20 gauge spinal catheter was introduced

through an 18-gauge Husted epidural needle. Cohen, Amar, Pantuck, Singer, & Divon (2002) retrospectively studied the effects of 24 to 48 hour intrathecal catheterization with continuous postoperative analgesia on the incidence of PDPH in cesarean section patients after accidental dural puncture. Of the 13 patients in this study, none developed a PDPH. In another study, where three patients experienced accidental dural puncture, epidural catheters were threaded into the intrathecal space. None of these patients experienced PDPH after removal of the catheters.

The mechanism by which subarachnoid catheters prevent PDPHs is not completely understood. The large gauge intrathecal catheters are thought to act as a plug and prevent CSF from leaking through the dural tear. During the active stage of labor the catheter is able to maintain adequate amounts of CSF within the meninges and is able to prevent leakage even with the increased abdominal pressures created during labor. The mechanism of action of the catheter is believed to be both an immediate and a delayed action. The immediate action of the catheter is to plug the tear in the dura, as discussed above. The delayed mechanism of action involves leaving the catheter in place for 24 or more hours. After 24 hours it is thought that the inflammatory response has been activated and these mediators are then responsible for closing the tear in the dura after the catheter has been removed. In the study by Ayad et al, (2003), the patients in group C were noted to have only a 6.2% PDPH rate verses group B, who had a 54.1% PDPH rate. The rate of PDPHs was decreased by 48% simply by leaving the catheter in place for 24-48 hours longer. This decrease may be explained by an increase of inflammatory mediators at the site of the dural tear, and subsequent fibrous formation around the tear with a resultant decreased loss of CSF.

Evans et al. (2000) believes that the evidence supports the placement of an intrathecal catheter after accidental dural puncture during attempted placement of an epidural catheter in order to reduce the risk of PDPH. The catheter should be left in place for 24 hours in order to allow the inflammatory response time to act on the dural tear. This may decrease the need for an epidural blood patch.

Physiology of Epidural Blood Patch

There are three primary theories explaining the mechanism of action by which a blood patch can provide symptom relief from a PDPH. The first is that the blood patch creates a blood clot that adheres to the dura mater, thereby sealing the hole in the dura and preventing further loss of CSF. The second theory is that the injected blood leads to an increase in intraspinal pressure, which in effect increases intracranial pressure, effectively reducing traction on the brain and supporting structures. The third theory is that the mixing of blood with the CSF leads to a rapid coagulation response, sealing the dural tear, even if it is far from the blood patch injection site (Hurtado & Clarkson 2007).

The appropriate timing for the administration of an epidural blood patch has been under debate. Some anesthesia practitioners have placed prophylactic blood patches immediately upon seeing CSF with an epidural placement. A study by Loeser, Hill, and Bennett (1978) found a 71% failure rate if the blood patch was placed within a 24 hour period of the dural puncture. The blood patches placed after a 24 hour period only had a 4% failure rate. Safa-Tisseront, Thormann, & Malassine (2001) noted that in a study of 504 patients who experienced PDPH from accidental dural puncture with an epidural needle, or intentional puncture with a spinal needle, 75% of the patients experienced complete relief with the administration of a blood patch. Additionally 18% experienced some relief and 7% had no relief.

According to Gaiser (2007) only 75 out of 1021 or 7.3% patients who received neuraxial anesthesia with either intentional or unintentional puncture of the dura experienced a PDPH. According to Vilming, Kloster and Sandvik (2005), in a study of 504 patients who were suffering from PDPH, 75% of these patients achieved complete relief, 18% achieved some relief, and 7% did not get any relief from an epidural blood patch. With these statistics in mind, it is important that health care providers who care for this population of patients be able to provide information and education to these patients regarding a plan of care and pain relief.

Vilming, Kloster, & Sandvik (2005) found that a blood patch should not be administered until after a 24 hour waiting period if the patient remains symptomatic. The 24 hour delay increases the success rate of the blood patch and decreases the length of the hospital stay. Angle, Tang, Thompson, & Szalai (2005) found that patients who experienced PDPH and were not treated with a blood patch had increased length of stay by 24 hours and were more likely to return to the emergency room for pain management.

Complications of Epidural Blood Patch

Complications of an epidural blood patch include pain at the injection site, parasthesias in the lower extremities, sensory disturbances in the lower extremities, weakness of the lower extremities, and walking disturbances (Hurtado & Clarkson, 2007). Sudlow & Warlow (2001) found that introduction of bacteria during the blood patch procedure may result in a spinal abscess or meningitis. Other complications may include cerebellar tonsillar herniation secondary to a subdural hematoma. The risk of another dural puncture is present any time this procedure is used and the risk of a spinal hematoma exists with any neuraxial anesthesia.

In a case study by Davies, Murphy, Smith, & O'Sullivan (2001) a 39 year old primagravida was noted to have a subdural hematoma which was undiagnosed for a 14 day period after the initial neuraxial anesthesia. The patient did experience a PDPH at 20 hours after the initial dural puncture. The patient was observed for another 28 hours and the headache did worsen. The patient was treated with a blood patch at that time and the headache did resolve. The patient was subsequently discharged from the hospital. After a 14 day period at home the patient noted recurrence of the headache with the accompanying symptoms of lethargy and expressive dysphagia. Numbness of her right hand and forearm were also noted at that time. The patient sought care with her primary MD, who referred her to the emergency room and from there to a neurologist. A MRI scan was performed and a left sided subdural hematoma with a midline shift was found. The patient was taken to surgery where a craniotomy and evacuation of the clot was performed. The patient recovered well and was discharged home 5 days after the surgery. After review of the case, the radiologist believed that the subdural bleed started at the time of the accidental dural puncture. The resultant loss of CSF created traction on the supporting structures of the brain. This coupled with vasodilation created a tear in the cerebral vessels and caused the subdural hematoma.

A case study by Winston & Norman (2003) followed a 24 year old parturient who complained of PDPH symptoms late in the first day post-partum. The patient was treated conservatively and was offered a blood patch. The patient refused the patch and was discharged home the following day. The patient returned to the emergency room on postpartum day 4 complaining of a severe headache and visual disturbances. The patient was treated with a blood patch at this time. Following the blood patch the patient reported relief from both the headache and the visual disturbances within ten minutes.

Summary of the Literature Review

Review of literature indicates that there is a marked increase in resolution of PDPHs with the use of a blood patch after a 24 hour waiting period from the time of dural puncture. The literature suggests a 70% success rate with the blood patch, as long as it is administered at least 24 hours after the unintentional dural puncture. Prophylactic blood patches that are administered immediately after a wet tap are not found to be helpful in the prevention of a PDPH. The administration of fluids, such as a saline bolus or infusion, has been associated with a decrease in the severity of a PDPH but has not been associated with resolution of a PDPH. . The placement of epidural catheters into the intrathecal space immediately after unintentional dural puncture has promising results if left in place for at least 24 hours. Further studies need to be done regarding the physiology of blood patches and the inflammatory response. The recommended waiting period for both blood patches and intrathecal catheter removal is 24 hours, however there are no studies indicating a specific timeline for clot or fibrous formations that seal the dural tear, if this in fact what occurs.

In conclusion, the review of literature and critique of research articles pertaining to PDPH and epidural blood patching indicates that while the incidence rate of PDPH is < 1%, the effects of PDPHs are debilitating. Symptoms of PDPH may last up to two weeks and reduce a patient's ability to cope with activities of daily living. Time may be lost from work, and return visits to the hospital or emergency room may be costly. Parturients in particular are affected due to their decreased ability to care for their newborn. Blood patches appear to be the gold standard for treating and providing relief from PDPHs, but there are risks associated with the procedure. CRNAs and SRNAs must be aware of the

treatment options and risks associated with these treatment options in order to provide information to their patients, so that they may make informed decisions.

CHAPTER III

METHOLOGY

Introduction

The use of epidural blood patching for the treatment of PDPHs has been shown to have a high rate of success. The complications and side effects of blood patches necessitate good patient education so that the patients may make well educated decisions. The alternatives to blood patching include conservative treatment with bed rest and fluids, as well as invasive treatments including continuous or bolus epidurals with saline products. Patients must be informed of the fact that these treatments often do not resolve the headaches but may only lessen their severity. Documentation of PDPHs lasting up to one year exists, but the majority of headaches resolve within a 14 day period. Patients also need to be educated regarding the risks of developing a PDPH after discharge home following neuraxial anesthesia. PDPHs may occur up to 7-10 days after neuraxial anesthesia. Adequate rest and maintenance of PO fluids helps to decrease the risks of PDPHs. Strenuous physical activity, or lifting more than 10 lbs may result in the loss of the clot which occludes the tear in the dura mater resulting in the loss of CSF and leading to a PDPH.

Target Audience

The data from this literature review was obtained primarily for the education of Certified Registered Nurse Anesthetists (CRNAs) and Student Registered Nurse Anesthetists (SRNAs) who work with patients that are at high risk for PDPHs, such as the

session which covered available options regarding treatment and management of PDPHs. Information included risks and complications of procedures involved. Education regarding the treatment options as well as the efficacy and timing of implementation of these treatments was included. The results of the differences between the pre and post-tests will indicate the effectiveness of the information session, if any exists. Questions from students following the presentation were answered after the post-test was collected.

Expected Results

The expected results of this project are based on the belief that there is a knowledge deficit regarding the pathophysiology, available treatments, and timing of the treatment options for PDPH. Upon completion of the power point presentation and question and answer session, the SRNAs should be able to identify high risk patients who are prone to PDPHs. Available treatment options and the timing of these treatments should also be understood by the SRNAs. The ultimate goal of this project was to create a better understanding by future nurse anesthetists of the cause of PDPHs as well as the best treatment options available. This information, through patient education, may also reduce the risk of developing a PDPH for patients who are discharged home after neuraxial anesthesia.

Nursing Practice

PDPHs are a serious potential complication associated with any type of neuraxial anesthesia. In an attempt to reduce the risk of PDPHs as well as identify and treat PDPHs effectively, CRNAs must be capable of identifying high risk patients, behaviors, and equipment associated with PDPHs. If a PDPH does result after neuraxial anesthesia the provider needs to be capable of informing the patient of available treatments and the timing of these treatments. With a thorough understanding of PDPHs, anesthesia providers will be better trained regarding the care they can provide for their patients.

Nursing Research

Research continues regarding treatment of PDPHs. New research involves blood patching under fluoroscopy. With more accurate placement of blood patches, better results are being seen. Patients will need to be informed of these options as the percentage of success may be even higher and include a decreased incidence of complications. Further research is needed regarding this procedure and the possible benefits verses increased costs associated with the procedure.

Nursing Education

Neuraxial anesthesia has increased in popularity due to the many benefits provided to the patients, primarily the safety of neuraxial anesthesia. In order to ensure safe and consistent care for our patients, it is vital that continuing education must be available for anesthesia providers. This education ensures that current information is available for providers, as this may reduce the risk of PDPHs and ensure that the best treatment options are chosen.

Nursing Policy

As stated above, if effective, this study may be used as an educational tool for the anesthesia and OB/GYN departments and implemented as a facility policy. Hospital policy may require all healthcare providers involved in neuraxial anesthesia or blood patching to complete an annual skills validation or in-service to ensure that competent care is provided to these patients.

Summary

In summary, the evidence shown in the literature review indicates that the most effective and rapid treatment for PDPHs is the epidural blood patch. Healthcare providers who are involved in the care of patients at high risk for PDPHs need to be aware of the

symptoms, as well as the available treatment options. Patients need to be aware of the risks and behaviors associated with spontaneous CSF leaks after being discharged home. Anesthesia providers need to be able to effectively educate their patients so that they may make informed decisions regarding their own care. The debilitating effects of a PDPH may incapacitate a patient for 10 – 14 days. The effects of the headaches has repercussions that encompass: (a) wound healing, (b) patient suffering, (c) quality of life, and (d) financial strains related to lost work time and increased medical costs. With comprehensive patient education, those affected will be capable of making decisions in their best interest, and hopefully decrease the amount of time that they are subjected to the symptoms of PDPHs.

CHAPTER IV

RESULTS

Introduction

The results of the pre and post tests have been evaluated and presented in a table format. Individual tables have been created for both the pre and post tests questionnaires. The tables shown incorporate the 11 questionnaire items and indicate the responses of the 12 participants as either C = correct or I = incorrect. The responses from the pre and post-test questionnaires were compared to determine if test scores improved following the power point presentation. Please refer to Table 1 for pre-test questionnaire results and Table 2 for post-test questionnaire results.

Marked improvement was noted with the post test questionnaire results. In comparing pre and post test questionnaires, question #3 showed improvement from 8 incorrect answers to 0 incorrect answers. Question #9 showed improvement from 6 incorrect to 1 incorrect answer, and question #12 went from 7 incorrect to 2 incorrect answers. Question #10 was eliminated from the findings as there was no correct answer in the options. It was noted that the students did write in the correct answer for question # 10 on the post test questionnaire. Questions #1, #6, and #7 were all correct on both the pre and post-test questionnaires. Overall there was an improvement from 30 incorrect answers on the pre-test questionnaire to 5 incorrect answers on the post-test questionnaire; this was including the exclusion of the #10 test question.

Table 2. Pre-test Questionnaire Results

Pre-test Questions	Participants By Number											
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Question #1 What factors influence the frequency of a PDPH?	C	C	C	C	C	C	C	C	C	C	C	C
Question #2 What are the characteristics of a PDPH?	C	C	I	C	C	C	C	C	C	C	C	C
Question #3 What is the percentage of incidence of PDPH following an inadvertent dural puncture?	I	I	I	C	C	I	I	I	C	I	C	I
Question #4 Which demographic group has the highest incidence of PDPH?	I	C	I	C	C	C	C	C	I	C	C	C
Question #5 Which needle used for neuraxial anesthesia has the highest incidence of PDPH?	I	C	C	C	C	C	C	C	C	C	I	C
Question #6 Which treatment modality has the highest efficacy rate?	C	C	C	C	C	C	C	C	C	C	C	C
Question #7 What form of blood product is used for a blood patch?	C	C	C	C	C	C	C	C	C	C	C	C
Question # 8 The incidence and severity of a PDPH following inadvertent dural puncture is decreased if a blood patch is immediately implemented following the procedure.	I	C	C	C	C	C	I	C	C	I	C	C
Question #9 A PDPH may occur with as small a loss of CSF as?	C	I	I	I	C	C	C	I	C	C	I	I
Question # 10 What volume of CSF is produced in the choroid plexus in a 24 hour period?	I	I	I	I	I	I	I	I	I	I	I	I
Question # 11 Briefly explain one of the theories for the etiology of a PDPH.	C	I	I	C	I	I	C	I	C	I	I	C

C = Correct Answer I = Incorrect Answer

Table 3. Post-test Questionnaire Results

Post-test Questions	Participants By Number											
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Question #1 What factors influence the frequency of a PDPH?	C	C	C	C	C	C	C	C	C	C	C	C
Question #2 What are the characteristics of a PDPH?	C	C	C	C	C	C	C	C	C	C	C	C
Question #3 What is the percentage of incidence of PDPH following an inadvertent dural puncture?	C	C	C	C	C	C	C	C	C	C	C	C
Question #4 Which demographic group has the highest incidence of PDPH?	C	C	C	C	C	C	C	C	I	C	C	C
Question #5 Which needle used for neuraxial anesthesia has the highest incidence of PDPH?	C	C	I	C	C	C	C	C	C	C	C	C
Question #6 Which treatment modality has the highest efficacy rate?	C	C	C	C	C	C	C	C	C	C	C	C
Question #7 What form of blood product is used for a blood patch?	C	C	C	C	C	C	C	C	C	C	C	C
Question # 8 The incidence and severity of a PDPH following inadvertent dural puncture is decreased if a blood patch is immediately implemented following the procedure.	C	C	C	C	C	C	C	C	I	C	C	C
Question #9 A PDPH may occur with as small a loss of CSF as?	C	C	C	I	C	C	C	C	C	C	C	C
Question # 10 What volume of CSF is produced in the choroid plexus in a 24 hour period?	C	C	C	C	C	C	C	C	C	C	C	C
Question # 11 Briefly explain one of the theories for the etiology of a PDPH	C	C	I	C	C	C	C	C	C	C	I	C

C = Correct Answer I = Incorrect Answer

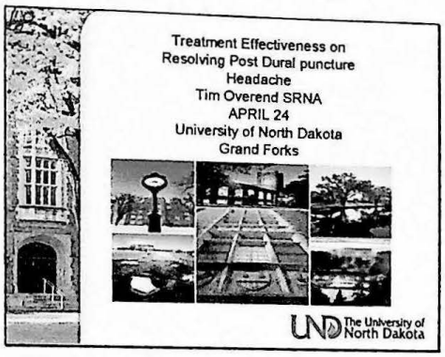
Summary

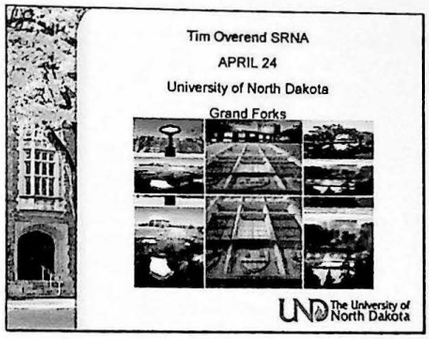
The need for a thorough understanding of all aspects of anesthesia care is necessary for safe clinical practice. The first year nurse anesthesia students performed well as evidenced by the marked increase from the pre to the post-test questionnaire scores. The presentation was delivered smoothly in an organized fashion and the students appeared attentive. An earlier presentation time may have been more conducive to learning. Overall, this was a positive learning experience for both myself as well as all those involved.

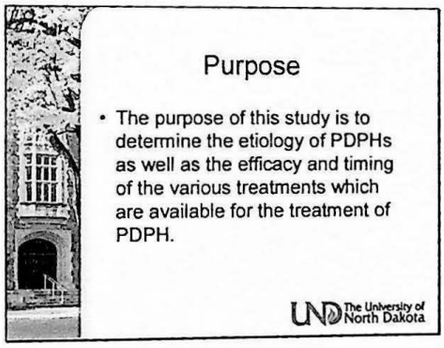
APPENDICES

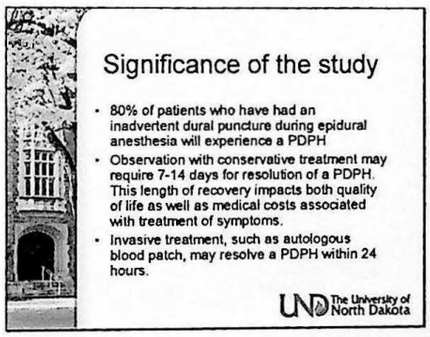
Appendix A

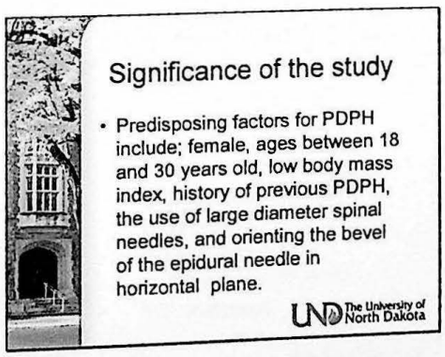
Power Point Presentation 1

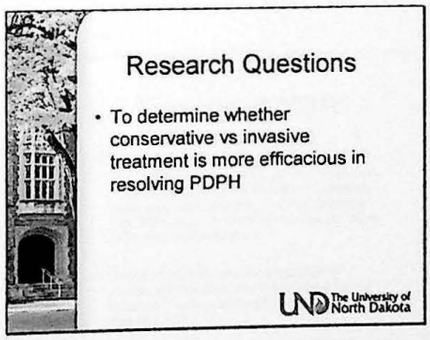


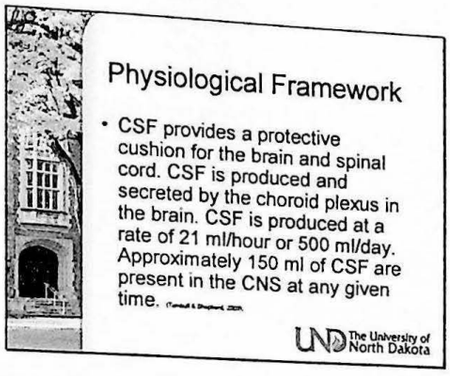


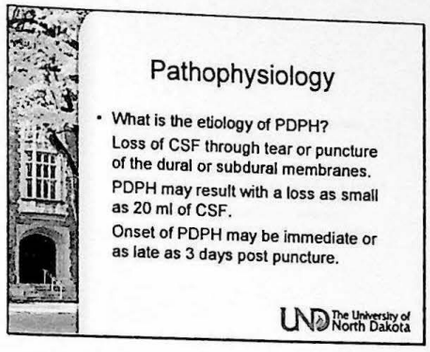


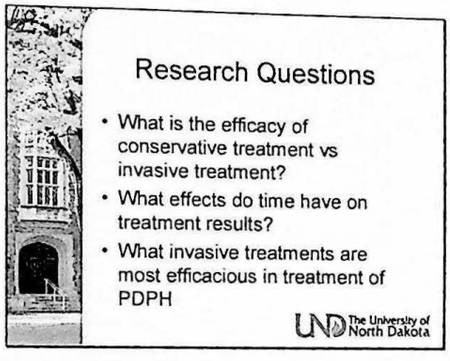


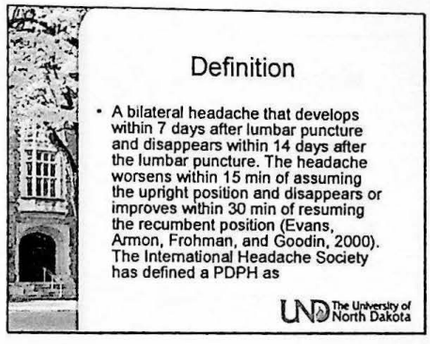


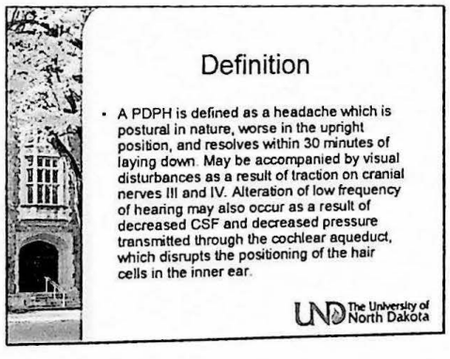


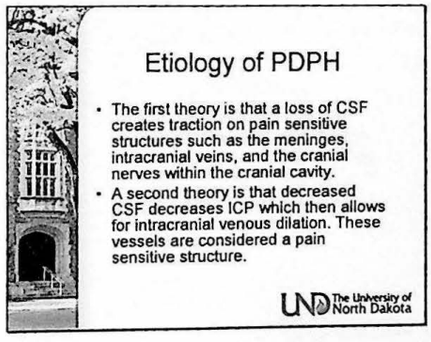

Physiological Framework
• CSF provides a protective cushion for the brain and spinal cord. CSF is produced and secreted by the choroid plexus in the brain. CSF is produced at a rate of 21 ml/hour or 500 ml/day. Approximately 150 ml of CSF are present in the CNS at any given time.
UND The University of North Dakota

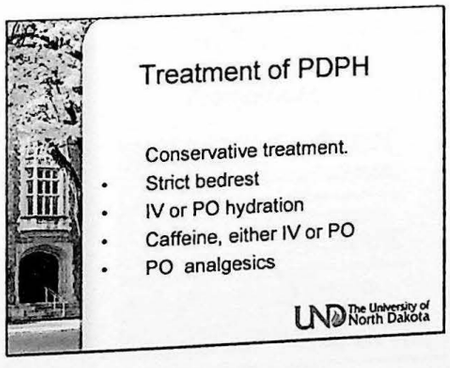

Pathophysiology
• What is the etiology of PDPH?
Loss of CSF through tear or puncture of the dural or subdural membranes.
PDPH may result with a loss as small as 20 ml of CSF.
Onset of PDPH may be immediate or as late as 3 days post puncture.
UND The University of North Dakota

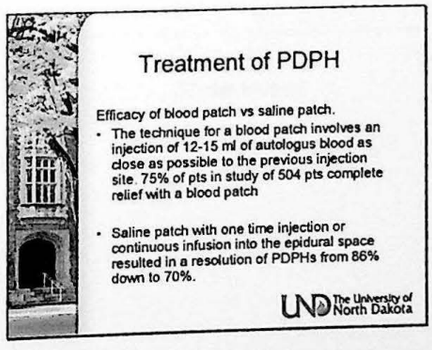

Research Questions
• What is the efficacy of conservative treatment vs invasive treatment?
• What effects do time have on treatment results?
• What invasive treatments are most efficacious in treatment of PDPH
UND The University of North Dakota

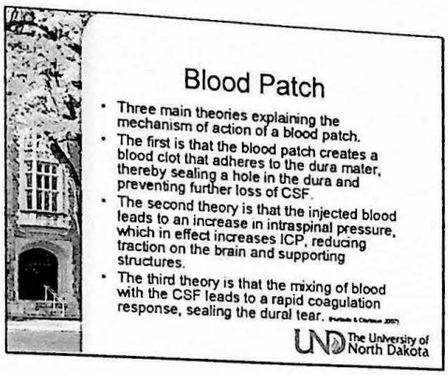

Definition
• A bilateral headache that develops within 7 days after lumbar puncture and disappears within 14 days after the lumbar puncture. The headache worsens within 15 min of assuming the upright position and disappears or improves within 30 min of resuming the recumbent position (Evans, Armon, Frohman, and Goodin, 2000). The International Headache Society has defined a PDPH as
UND The University of North Dakota

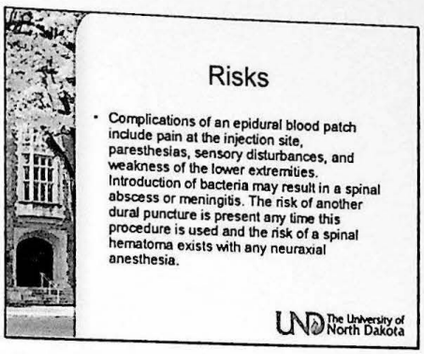

Definition
• A PDPH is defined as a headache which is postural in nature, worse in the upright position, and resolves within 30 minutes of laying down. May be accompanied by visual disturbances as a result of traction on cranial nerves III and IV. Alteration of low frequency of hearing may also occur as a result of decreased CSF and decreased pressure transmitted through the cochlear aqueduct, which disrupts the positioning of the hair cells in the inner ear.
UND The University of North Dakota

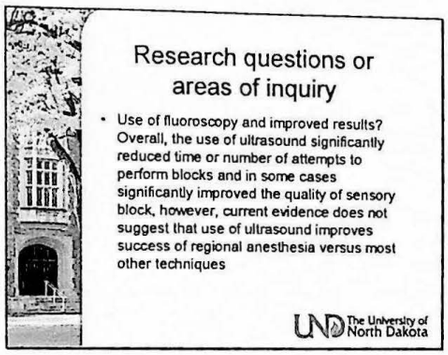

Etiology of PDPH
• The first theory is that a loss of CSF creates traction on pain sensitive structures such as the meninges, intracranial veins, and the cranial nerves within the cranial cavity.
• A second theory is that decreased CSF decreases ICP which then allows for intracranial venous dilation. These vessels are considered a pain sensitive structure.
UND The University of North Dakota

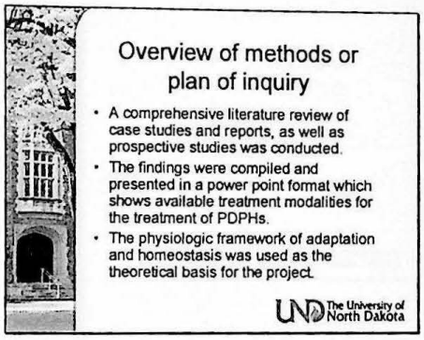

Treatment of PDPH
Conservative treatment.
• Strict bedrest
• IV or PO hydration
• Caffeine, either IV or PO
• PO analgesics
UND The University of North Dakota

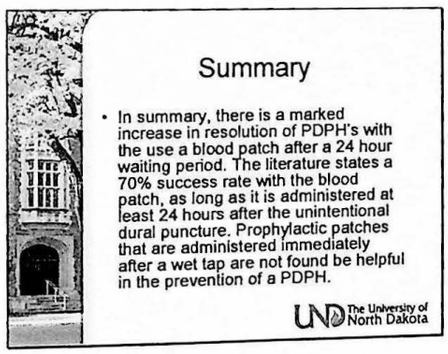

Treatment of PDPH
Efficacy of blood patch vs saline patch.
• The technique for a blood patch involves an injection of 12-15 ml of autologus blood as close as possible to the previous injection site. 75% of pts in study of 504 pts complete relief with a blood patch
• Saline patch with one time injection or continuous infusion into the epidural space resulted in a resolution of PDPHs from 86% down to 70%.
UND The University of North Dakota

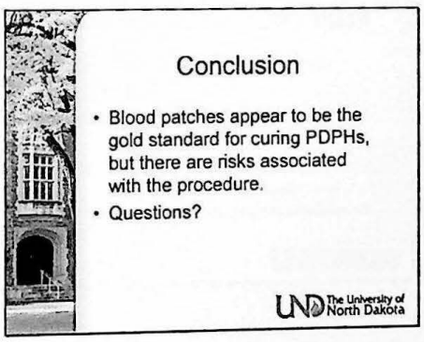

Blood Patch
• Three main theories explaining the mechanism of action of a blood patch.
• The first is that the blood patch creates a blood clot that adheres to the dura mater, thereby sealing a hole in the dura and preventing further loss of CSF.
• The second theory is that the injected blood leads to an increase in intraspinal pressure, which in effect increases ICP, reducing traction on the brain and supporting structures.
• The third theory is that the mixing of blood with the CSF leads to a rapid coagulation response, sealing the dural tear.
UND The University of North Dakota

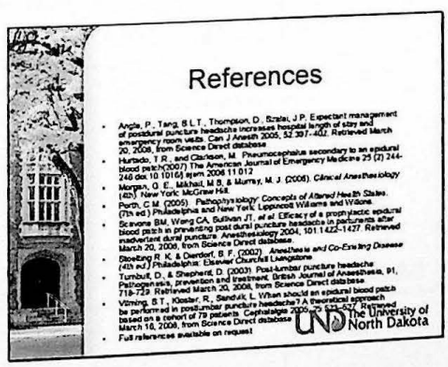

Risks
• Complications of an epidural blood patch include pain at the injection site, paresthesias, sensory disturbances, and weakness of the lower extremities. Introduction of bacteria may result in a spinal abscess or meningitis. The risk of another dural puncture is present any time this procedure is used and the risk of a spinal hematoma exists with any neuraxial anesthesia.
UND The University of North Dakota

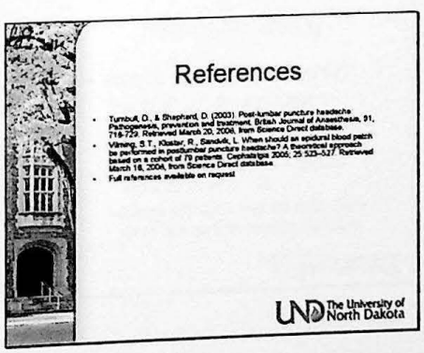

Research questions or areas of inquiry
• Use of fluoroscopy and improved results? Overall, the use of ultrasound significantly reduced time or number of attempts to perform blocks and in some cases significantly improved the quality of sensory block, however, current evidence does not suggest that use of ultrasound improves success of regional anesthesia versus most other techniques
UND The University of North Dakota


Overview of methods or plan of inquiry
• A comprehensive literature review of case studies and reports, as well as prospective studies was conducted.
• The findings were compiled and presented in a power point format which shows available treatment modalities for the treatment of PDPHs.
• The physiologic framework of adaptation and homeostasis was used as the theoretical basis for the project.
UND The University of North Dakota


Summary
• In summary, there is a marked increase in resolution of PDPH's with the use a blood patch after a 24 hour waiting period. The literature states a 70% success rate with the blood patch, as long as it is administered at least 24 hours after the unintentional dural puncture. Prophylactic patches that are administered immediately after a wet tap are not found be helpful in the prevention of a PDPH.
UND The University of North Dakota

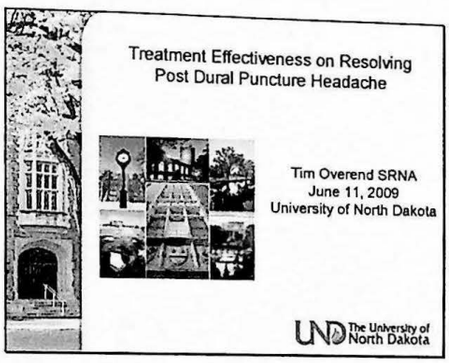

Conclusion
• Blood patches appear to be the gold standard for curing PDPHs, but there are risks associated with the procedure.
• Questions?
UND The University of North Dakota

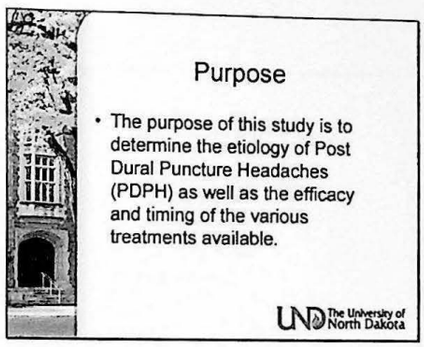

References
• Angle, P., Tang, S.L.T., Thompson, D., Brake, J.P. Expectant management of postdural puncture headache increases hospital length of stay and emergency room visits. Can J Anesth 2005, 52 397.-402. Retrieved March 20, 2008, from Science Direct database
• Hurtado, T.R., and Clarkson, M. Pneumocephalus secondary to an epidural blood patch?(2007) The American Journal of Emergency Medicine 25 (2) 244-246 doi:10.1016/j.ajem.2006.11.012
• Morgan, G.E., Mikhail, M.S. & Murray, M.J. (2006). Clinical Anesthesiology (4th) New York: McGraw Hill.
• Porth, C.M. (2005). Pathophysiology: Concepts of Altered Health States. (7th ed.) Philadelphia and New York: Lippincott Williams and Wilkins.
• Scavone BM, Wang CA, Sullivan JT, et al. Efficacy of a prophylactic epidural blood patch in preventing post dural puncture headache in parturients after inadvertent dural puncture. Anesthesiology 2004; 101:1422-1427. Retrieved March 20, 2008, from Science Direct database.
• Stoelting R. K. & Dierdorf, S. F. (2002). Anesthesia and Co-Existing Disease (4th ed.) Philadelphia: Elsevier Churchill Livingstone
• Turnbull, D., & Shepherd, D. (2003) Post-lumbar puncture headache: Pathogenesis, prevention and treatment. British Journal of Anaesthesia, 91, 718-729. Retrieved March 20, 2008, from Science Direct database
• Vilming, S.T., Klaster, R., Stendvik, L. When should an epidural blood patch be performed in post-lumbar puncture headache? A theoretical approach based on a cohort of 79 patients. Cephalalgia 2005; 25 523-527. Retrieved March 18, 2008, from Science Direct database
• Full references available on request
UND The University of North Dakota

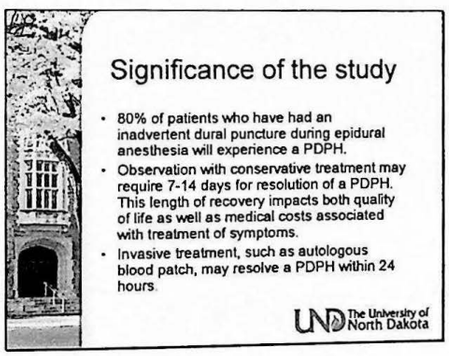

References
• Turnbull, D., & Shepherd, D. (2003) Post-lumbar puncture headache: Pathogenesis, prevention and treatment. British Journal of Anaesthesia, 91, 718-729. Retrieved March 20, 2008, from Science Direct database
• Vilming, S.T., Klaster, R., Stendvik, L. When should an epidural blood patch be performed in post-lumbar puncture headache? A theoretical approach based on a cohort of 79 patients. Cephalalgia 2005; 25 523-527. Retrieved March 18, 2008, from Science Direct database
• Full references available on request
UND The University of North Dakota

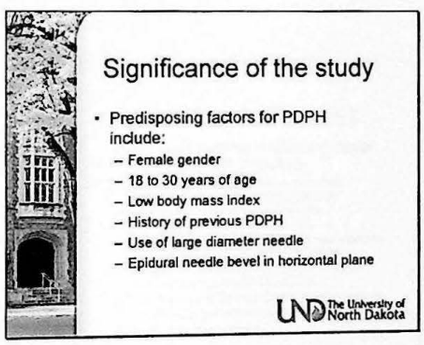
Appendix B

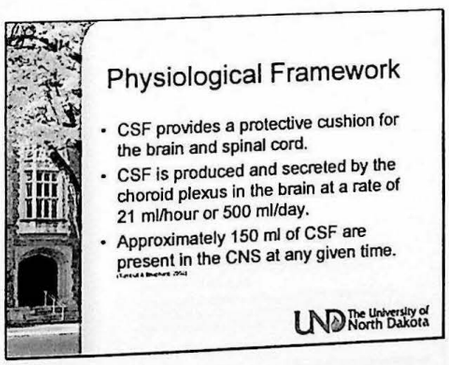
Power Point Presentation 2

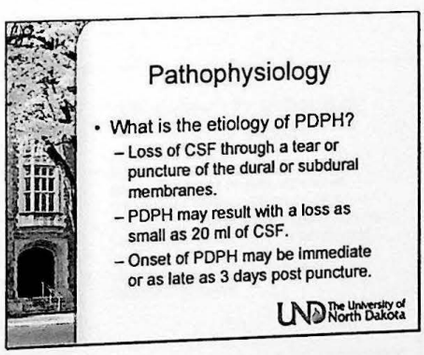


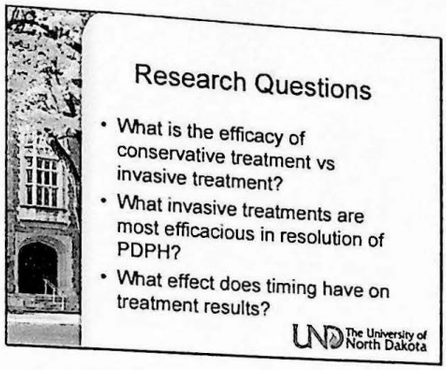


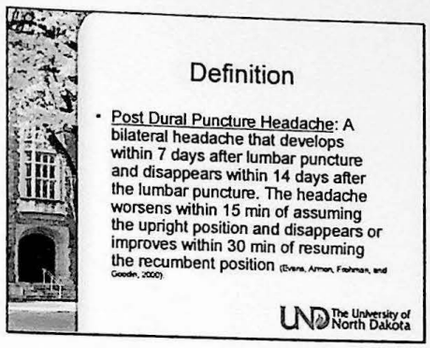


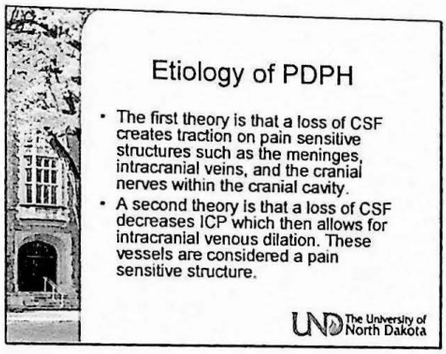


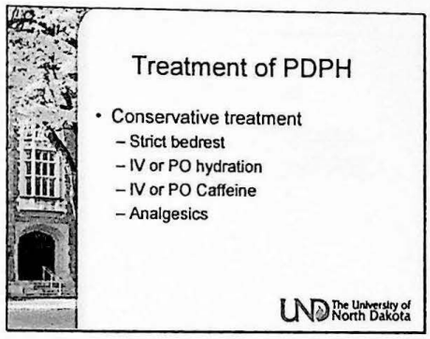


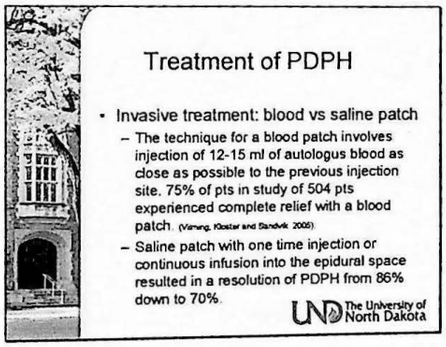


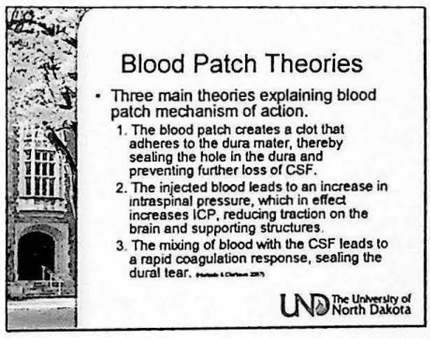

Research Questions
• What is the efficacy of conservative treatment vs invasive treatment?
• What invasive treatments are most efficacious in resolution of PDPH?
• What effect does timing have on treatment results?
UND The University of North Dakota

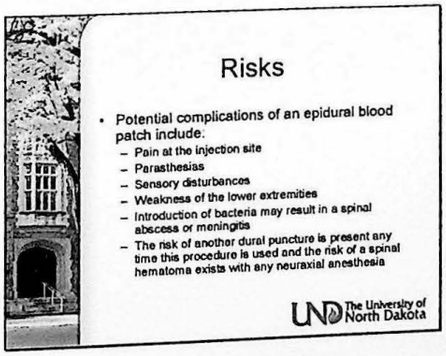

Definition
• Post Dural Puncture Headache: A bilateral headache that develops within 7 days after lumbar puncture and disappears within 14 days after the lumbar puncture. The headache worsens within 15 min of assuming the upright position and disappears or improves within 30 min of resuming the recumbent position (Evans, Armon, Frishman, and Goodin, 2000)
UND The University of North Dakota

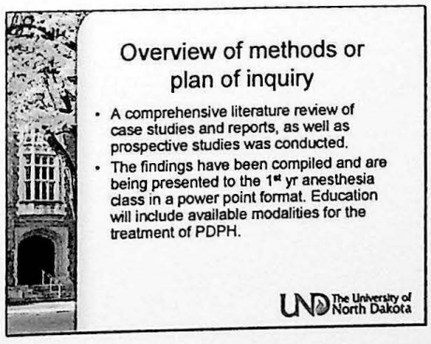

Etiology of PDPH
• The first theory is that a loss of CSF creates traction on pain sensitive structures such as the meninges, intracranial veins, and the cranial nerves within the cranial cavity.
• A second theory is that a loss of CSF decreases ICP which then allows for intracranial venous dilation. These vessels are considered a pain sensitive structure.
UND The University of North Dakota

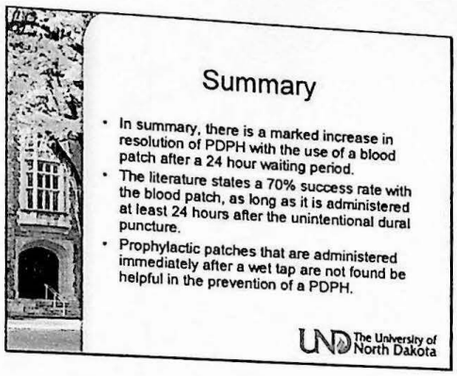

Treatment of PDPH
• Conservative treatment
– Strict bedrest
– IV or PO hydration
– IV or PO Caffeine
– Analgesics
UND The University of North Dakota

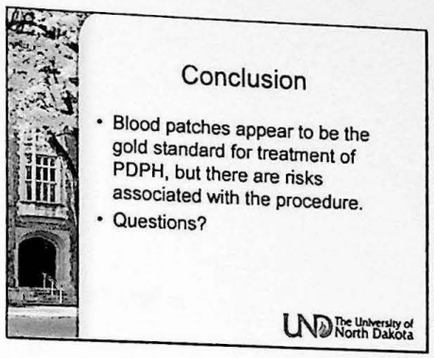

Treatment of PDPH
• Invasive treatment: blood vs saline patch
– The technique for a blood patch involves injection of 12-15 ml of autologus blood as close as possible to the previous injection site. 75% of pts in study of 504 pts experienced complete relief with a blood patch. (Vilming, Klostar and Sandvik, 2005)
– Saline patch with one time injection or continuous infusion into the epidural space resulted in a resolution of PDPH from 86% down to 70%.
UND The University of North Dakota

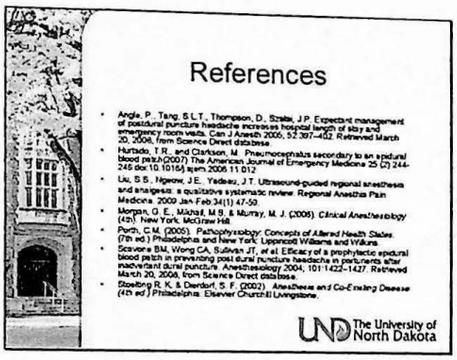

Blood Patch Theories
• Three main theories explaining blood patch mechanism of action.
1. The blood patch creates a clot that adheres to the dura mater, thereby sealing the hole in the dura and preventing further loss of CSF.
2. The injected blood leads to an increase in intraspinal pressure, which in effect increases ICP, reducing traction on the brain and supporting structures.
3. The mixing of blood with the CSF leads to a rapid coagulation response, sealing the dural tear.
UND The University of North Dakota

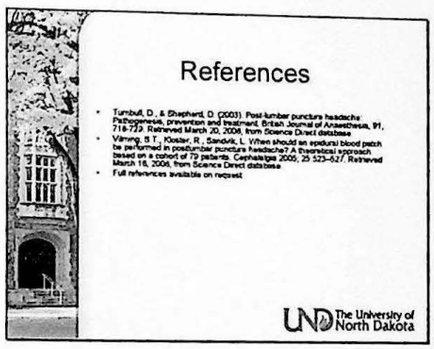

Risks
• Potential complications of an epidural blood patch include:
– Pain at the injection site
– Parasthesias
– Sensory disturbances
– Weakness of the lower extremities
– Introduction of bacteria may result in a spinal abscess or meningitis
– The risk of another dural puncture is present any time this procedure is used and the risk of a spinal hematoma exists with any neuraxial anesthesia
UND The University of North Dakota


Overview of methods or plan of inquiry
• A comprehensive literature review of case studies and reports, as well as prospective studies was conducted.
• The findings have been compiled and are being presented to the 1st yr anesthesia class in a power point format. Education will include available modalities for the treatment of PDPH.
UND The University of North Dakota


Summary
• In summary, there is a marked increase in resolution of PDPH with the use of a blood patch after a 24 hour waiting period.
• The literature states a 70% success rate with the blood patch, as long as it is administered at least 24 hours after the unintentional dural puncture.
• Prophylactic patches that are administered immediately after a wet tap are not found be helpful in the prevention of a PDPH.
UND The University of North Dakota


Conclusion
• Blood patches appear to be the gold standard for treatment of PDPH, but there are risks associated with the procedure.
• Questions?
UND The University of North Dakota


References
UND The University of North Dakota


References
UND The University of North Dakota

Appendix D

Pre-test/Post-test Questionnaire

Treatment Effectiveness on Resolving Post Dural Puncture Headache Quiz

1. Which factors influence the frequency of a PDPH?
   a. Age
   b. Female gender
   c. Large diameter needle
   d. Angle and direction of the needle
   e. All of the above

2. What are the characteristics of a PDPH?
   a. Aura.
   b. Postural in nature with photophobia and tinnitus.
   c. Associated with hallucinations
   d. Decrease with activity

3. What is the percentage of incidence of PDPH following an inadvertent dural puncture?
   a. 20%
   b. 40%
   c. 60%
   d. 80%

4. Which demographic group has the highest incidence of PDPH?
   a. Men > 50 years of age
   b. Men < 50 years of age
   c. Women > 50 years of age
   d. Women < 50 years of age

5. Which needle used for neuraxial anesthesia has the highest incidence of PDPH.
   a. 25 ga Sprotte
   b. 27 ga Quincke
   c. 27 ga Whitacre
   d. 18 ga Touhy

6. Which treatment modality has the highest efficacy rate for resolving an ongoing postdural puncture headache?
   a. Saline Patch
   b. Blood patch
   c. Caffeine infusion
   d. Oral analgesics

7. What form of blood product is used for a blood patch?
   a. FFP
   b. Fresh autologus blood
   c. Blood banked blood
   d. Cryoprecipitate

8. The incidence and severity of a PDPH following inadvertent dural puncture is decreased if a blood patch is immediately implemented following the procedure.
   a. True
   b. False

9. A PDPH may occur with as small a loss of CSF as?
   a. 5 ml
   b. 20 ml
   c. 50 ml
   d. 75 ml

10. What volume of CSF is produced in the choroid plexus in a 24 hour period?
    a. 50 ml
    b. 100 ml
    c. 150 ml
    d. 200 ml

11. Briefly explain one of the theories for the etiology of a Postdural Puncture Headache.

References

Angle, P., Tang, S.L.T., Thompson, D., Szalai, J.P. (2005). Expectant management of postdural puncture headache increases hospital length of stay and emergency room visits. *Canadian Journal Anesthesia, 52,* 397–402.

Ayad, S., Demian, Y.Narouze, S.N., and Tetzlaff, J.E. (2003). Subarachnoid catheter placement after wet tap for analgesia in labor: Influence on the risk of headache in obstetric patients anesthesiology. *Anesthesia Analgesia, 111,* 1112–1117.

Cohen, S., Amar, D., Pantuck, E.J., Singer, N. and Divon, M. (2002). Decreased incidence of headache after accidental dural puncture in cesarean delivery patients receiving continuous postoperative intrathecal analgesia. *Anesthesiology, 27*(2), 716–718.

Davies J.M., Murphy A., Smith M., and O'Sullivan G. (2001). Efficacy of blood patching for post dural puncture headaches. *British Journal of Anaesthesia, 86*(5), 720-723.

Denny, N., Masters, R., Pearson, D., Read, J. Sihota M., and Selander, D. (1987). Postdural puncture headache after continuous spinal anesthesia. *Anesthesia Analgesia, 66*, 791–794.

Evans, R.W., Armon, C., Frohman, E.M., Goodin, D.S. (2000). Assessment: Prevention of post-lumbar puncture headaches: Report of the therapeutics and technology assessment subcommittee of the American Academy of Neurology. *Neurology, 55*, 909–914.

Gaiser, R. (2006). Postdural puncture headache. *Current Opinion Anesthesiology, 19,* 249–253.

Gormley, J.B. (1960). Treatment of post spinal headache. *Anesthesiology, 21,* 565–566.

Homer, M. (2002). Evaluation of a spinal headache. *Topics in Emergency Medicine, 24*(1), 31-35.

Hurtado, T.R., and Clarkson, M. (2007). Pneumocephalus secondary to an epidural blood Patch. *The American Journal of Emergency Medicine, 25*(2), 244-246.

Kang, S.B, Goodnough, D.E, Lee, Y.K, et al. (1992). Comparison of 26 and 27 gauge needles for spinal anesthesia for ambulatory surgery patients. *Anesthesiology, 76,* 734–738.

Levine, D. N., & Rapalino, O. (2001). The pathophysiology of lumbar puncture Headache. *Journal of the Neurological Sciences, 192,* 1-8.

Lee, L.C., Sennett, M., Erickson, J.M. (2007). *Journal of Pediatric Oncology Nursing,* July-August v24 i4, 200(8).

Loeser, E.A, Hill, G.E, Bennett, G.M, et al. (1978). Time vs. success rate for epidural blood patch. *Anesthesiology, 49,* 147–148.

Lybecker, H., Moller, J.T., May, O., Nielsen, H.K. (1999). Incidence and prediction of postdural puncture headache: A prospective study of 1021 spinal anesthesias. *Anesthesia Analgesia, 70,* 389–394.

Miller, R. D. (Ed.). (2005). *Miller's Anesthesia* (6th). Philadelphia: Elsevier Churchill Livingstone.

Morgan, G. E., Mikhail, M.S, & Murray, M. J. (2006). *Clinical Anesthesiology* (4th). New York: McGraw Hill.

O'Connor, G., Gingrich, R., & Moffat, M. (2007). The effect of spinal needle design, size, and penetration angle on dural puncture cerebral spinal fluid loss. *AANA Journal, 75*(2), 111-116.

Porth, C.M. (2005). *Pathophysiology: Concepts of Altered Health States* (7th ed.). Philadelphia and New York: Lippincott Williams and Wilkins.

Safa-Tisseront, V., Thormann, F., Malassine, P. (2001). Effectiveness of epidural blood patch in the management of postdural puncture headache. *Anesthesiology, 95,* 334–339.

Santanen, U., Rautoma, P., Luurila, H., *et al.* (2004). Comparison of 27-gauge Whitacre and Quincke spinal needles with respect to postdural puncture headache and nondural puncture headache. *Acta Anaesthesiology Scandinavia, 48,* 474–479.

Scavone BM, Wong CA, Sullivan JT, *et al.* (2004). Efficacy of a prophylactic epidural blood patch in preventing post dural puncture headache in parturients after inadvertent dural puncture. *Anesthesiology, 101*, 1422–1427.

Stoelting R. K. & Dierdorf, S. F. (2002). *Anesthesia and Co-Existing Disease* (4th ed.). Philadelphia: Elsevier Churchill Livingstone.

Sudlow C, Warlow C. (2001). Epidural blood patching for preventing and treating postdural puncture headache. *Cochrane Database of Systematic Reviews,* Issue 2. Art. No.: CD001791. DOI: 10.1002/14651858.CD001791.

Turnbull, D., & Shepherd, D. (2003). Post-lumbar puncture headache: Pathogenesis, prevention and treatment. *British Journal of Anaesthesia, 91,* 718-729.

Vandam L.D, Dripps R.D. (1994). Long-term follow-up of patients who received 10,098 spinal anesthetics. *JAMA*, 156, 1486–1491.

Vilming, S.T., Kloster, R., Sandvik, L. (2005). When should an epidural blood patch be performed in postlumbar puncture headache? A theoretical approach based on a cohort of 79 patients. *Cephalalgia, 25,* 523–527.

Warwick, W., Neal, J.M. (2007). Beyond spinal headache: Prophylaxis and treatment of low-pressure headache syndromes. *Regional Anesthesia and Pain Medicine, 32*(5), 455-461.

Winston, A.W., Norman, D. (2003). Late postpartum eclampsia coincident with postdural puncture headache: A case report. *AANA Journal, 71*(5), 371-372.

Yücel, A., Özyalçin, S., Talu, G.K., Yücel, E.C., and Erdine, S. (1999). Intravenous administration of caffeine sodium benzoate for postdural puncture headache. *Regional Anesthesia and Pain Medicine, 24*(1), 51-54.