Comparison of dural repair techniques

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Abstract

**BACKGROUND CONTEXT:** Incidental durotomy occurs in 1% to 17% of lumbar spine surgery. This is treated with watertight suture repair, often combined with a sealant.

**PURPOSE:** To compare the hydrostatic strength of dural repair using various suture sizes, closure techniques, and adhesives.

**STUDY DESIGN:** A novel in vitro hydrostatic calf spine model.

**OUTCOME MEASURES:** Dural leakage as a function of hydrostatic pressure and leak area.

**METHODS:** We compared surgical repair between 5-0 surgilon and 6-0 prolene suture, continuous locked versus interrupted suture, and the effectiveness of three adhesives hydrogel, cyanoacrylate, and fibrin glue. The leakage flow rate was compared among suture groups using analysis of variance (ANOVA). The percent reduction of leak area was determined for the sealants and compared using ANOVA. The study was funded from an intramural departmental grant.

**RESULTS:** 6-0 Prolene was found to have significantly decreased leakage flow rate than 5-0 surgilon. We found no significant differences in the flow rate between the interrupted and continuous locked sutures. In most cases, leakage occurred from the needle holes around sutures. There was an 80% reduction in leak area with the hydrogel and cyanoacrylic sealants compared with only a 38% reduction with fibrin glue; however, there was no statistical difference between the leak rates using any of the sealants.

**CONCLUSION:** 6-0 Prolene using either interrupted or locked techniques was the best at creating watertight closure of an incidental durotomy. If a watertight seal cannot be obtained, a hydrogel or a fibrin sealant will immediately improve the strength of repair. Newer sutures that have a larger diameter of suture relative to needle should be developed for use in dural repair.

Keywords: Incidental durotomy; Cerebral spinal fluid leak; Dural repair; Fibrin glue; Complication: spinal surgery

Introduction

Incidental durotomy occurs in 1% to 17% of lumbar spine and in 1% of cervical spine surgeries [1,2]. This is a relatively common occurrence, and some authors report no change in the long-term results after spine surgery complicated by an incidental durotomy [3–5]. However, the sequelae from a dural tear, either cervical or lumbar, are not always benign. Direct consequences from a dural tear include headache, meningeal pseudocyst formation, or dural cutaneous fistulas leading to arachnoiditis, delayed wound healing, or a wound infection. Indirect consequences associated with prolonged flat bed rest that is often required include pneumonia, pressure ulcers, deep venous thrombosis and pulmonary embolism, and aspiration. Goodkin and Laska [6] reported that despite their usual benign outcome, there are often medicolegal implications from incidental durotomy.

The goals of dural repair include containment of nerve roots and watertight closure to allow early mobilization of the patient. Prevention of meningocele and fistula is also of prime importance. The actual treatment for an incidental durotomy depends on the size and location of the tear. In
the cervical spine, if accessible, the dural injury should be repaired primarily. If the tear is not accessible, then observation, glue, or a cerebrospinal fluid shunt is used [1,7]. In the lumbar spine, primary repair is recommended. A period of bed rest is often prescribed after the repair of a durotomy in the lumbar spine [8,9].

Many dural repair techniques have been described from simple interrupted sutures and sealants to laser tissue welding, biodegradable staples, and different types of grafts and patches [9–15]. Typically, sutures alone are used to close simple durotomies. The suture technique is based on surgeon preference with the goal of a watertight dural closure. For microsurgical anastomosis, simple interrupted suture technique has been considered the gold standard [9,16]. It has also been shown to be more time consuming than a running locked technique, with similar outcomes [17]. Cain et al. [18] showed that there was no significant difference in leak pressure using interrupted versus running locked suture technique in a dural repair model. However, he later reported an in vitro study that showed simple interrupted sutures used in a linear dural tear leaked at a lower pressure than dura repaired with running locked sutures [19].

Basic research studies have evaluated the effectiveness of sealants. Cain et al. [18] compared suture alone with suture augmented with either cyanoacrylate or fibrin glue. When the strength to failure was tested, it was shown that the pressure causing leakage was greater when suture repairs were augmented with sealants. They also found cyanoacrylate more effective than fibrin glue. However, cyanoacrylate is neurotoxic and not approved for dural repair although still used as a sealant. Hadley et al. [20] used a canine model to compare dural closure with suture, laser patch weld, and fibrin glue patch. This study showed that fibrin glue was superior to both laser patch weld and suture alone. We have been using a new product, a hydrogel sealant formed from trilysine amine and polyethylene glycol ester. This has proved promising in the clinical realm, with easy application and less potential adverse affects because of its synthetic nature [21]. Because of a paucity of information regarding basic efficacy of this product, we became interested in developing a model to test dural repair techniques.

The purpose of this study is to compare the hydrostatic strength of a variety of dural repair methods. To perform this comparison, a novel animal model for dural repair was developed. We will compare interrupted and running locked suture repairs of several sizes and three suture repairs augmented with a tissue adhesive.

Materials and methods

Model

Fresh calf spines were obtained from a local meat packing company (Strauss Veal and Lamb, Hales Corner, WI, USA) consisting of the T11–L5 spinal column including the surrounding soft tissue and an intact spinal cord and dura. Two 14 French two-way Foley catheters were placed into the dural space, one cranially and one caudally. These were advanced until they were positioned above and below the spinal segment to be tested. The caudal Foley catheter was clamped with a hemostat. The cranial Foley catheter was connected to a reservoir of normal saline via continuous bladder irrigation tubing and a drip chamber. The balloons in each catheter were inflated to isolate the spinal segment to be tested. Between the Foley and the reservoir, there is a clamp and a pressure transducer (Transpac IV monitoring kit with disposable transducer; Abbott Critical Care Systems, North Chicago, IL, USA) (Fig. 1).

With the Foley catheters positioned, the clamp was opened from the reservoir into the cranial Foley catheter and saline was infused into the dural space. The pressure transducer was used to determine the pressure within the system at the level of the spinal canal. As the reservoir was raised, the pressure in the system increased. The pressure in the system was changed by elevation of the reservoir and ranged from 30 to 80 mmHg. This was consistent with the measurements of cranial to caudal spinal column heights from the shortest and tallest physicians in our department.

When fully pressurized, the flow rate of the fluid into the system was measured by counting drops per minute from the drip chamber of the reservoir. The drip chamber produces a uniform droplet of 0.087 cc. Because there were leaks in the system, the flow rate of the intact segment was measured at 30 to 80 mmHg at increments of 10 mmHg. The leaks resulted from flow out amputated nerve root sleeves and incomplete obstruction from the balloons. Once the baseline flow rate was obtained, a 4-cm laminectomy in length was performed and extended laterally until flush with the medial edge of the pedicles (Fig. 2, Top). To ensure no dural injury occurred during the laminectomy, the flow rate from 30 to 80 mmHg was retested; this result was used for normalization in all later