



Ventriculo-humeral shunt: a cadaveric feasibility study with application to treating hydrocephalus

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Abstract

Purpose Intraosseous vascular access is often used when vascular access is difficult. However, the use of this space for a receptacle for cerebrospinal fluid (CSF) diversion has been scantily considered.

Materials and methods Six upper limbs of fresh frozen cadavers were used for this study. In the supine position, a small hole was drilled through the outer cortex of the proximal humerus and into the medullary cavity. A 16-gauge needle was placed into the hole in the humerus and 150 cc of saline infused. Next, the adjacent axillary vein and tributaries were dissected to observe dilation or the presence of the blue-colored saline. For part two of the study, shunt tubing was passed subcutaneously from a supraclavicular incision to the hole made in the humerus. Range of motion of the shoulder was then performed.

Results On all sides, all 150 cc of fluid was easily infused into the humerus. No specimen was found to have leakage from the drill hole site or into the extravascular soft tissues. With dissection of the axillary vein and its tributaries, all sides were found to have engorgement of these vessels. No tension was placed on the distal shunt tubing with full range of motion of the shoulder.

Conclusion Based on our study, the humerus is another option available to the neurosurgeon for CSF diversion.

Keywords Ventricular shunts · Humerus · Hydrocephalus · Intraosseous

Introduction

Intraosseous (IO) vascular access has been used for almost 100 years [3, 30] and is used when venous access is difficult or contraindicated [9]. Nosik performed the first ventriculomastoidectomy for CSF diversion in hydrocephalus in 1947 [14]. Modifications of this technique were made over the following years [7, 22].

As neurosurgeons are often in need of alternative sites to place CSF diversionary shunts, we theorized that the intraosseous placement of a CSF diversionary shunt tubing into the humerus might be an option for such procedures. Therefore, the following cadaveric feasibility study was performed.

Materials and methods

Six upper limbs from three adult fresh frozen cadavers were used for this study (Fig. 1). The mean age at death of the cadavers was 68.5 years. Two specimens were male and one was female. In the supine position, a small skin incision (~2.5 cm) was made at approximately the junction between the upper one-third and lower two-thirds of the arm (Fig. 2). This location was on the anterior humerus just distal to the attachment of the deltoid muscle onto the humerus and lateral to the biceps brachii and brachialis muscles. The overlying periosteum was dissected away and a small hole (2-mm diameter) drilled through the outer cortex of the humerus and into the medullary cavity (Fig. 2). A self-retaining retractor was placed. Next, a 16-gauge needle was placed into the hole in the humerus and glue applied around its periphery to ensure that no fluid would leak out. IV tubing was then attached to the needle and blue-colored saline infused with an attached syringe. One hundred fifty cubic centimeters were manually infused into the humerus with observation of leakage and ease of flow. The adjacent axillary vein and tributaries were dissected to observe dilation or the presence of the blue-colored saline (Fig. 3).

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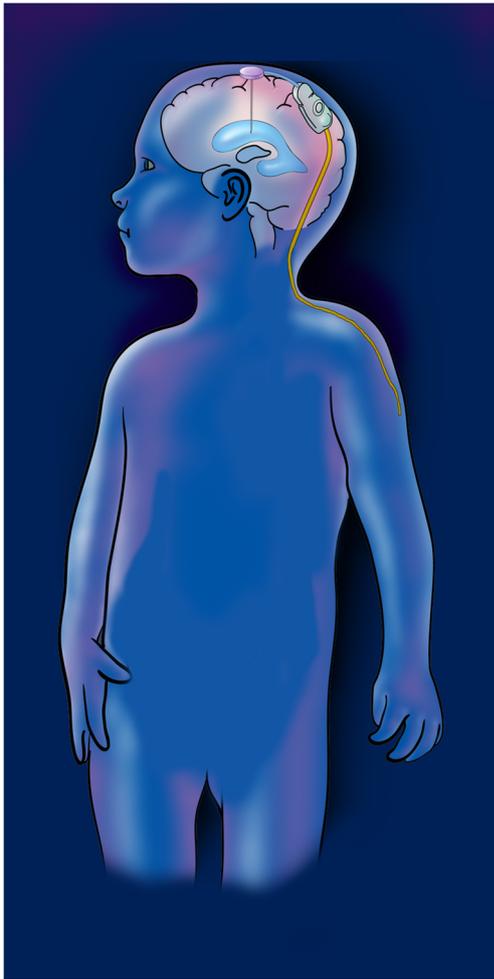


Fig. 1 Schematic drawing of the ventriculo-humeral shunt

For part two of the study, shunt tubing was passed subcutaneously from a supraclavicular incision to the hole made in the humerus (Fig. 4). Approximately 4 cm of shunt tubing was placed into the humerus. Range of motion of the shoulder was then performed.

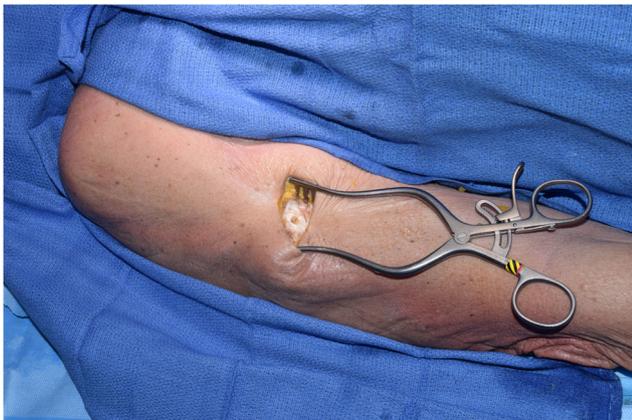


Fig. 2 Skin incision and drill hole into the right humerus

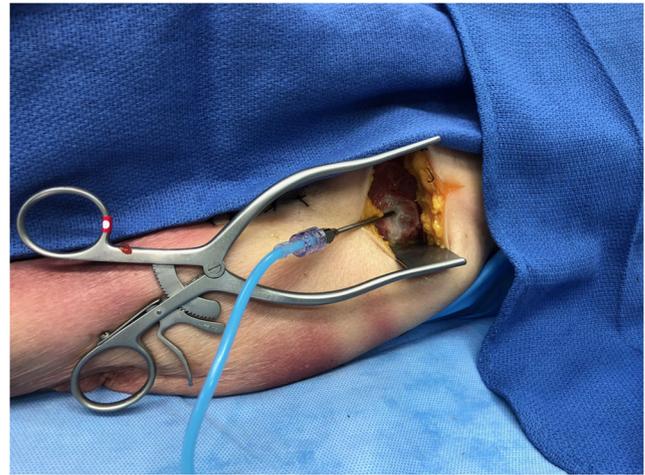


Fig. 3 Infusion of blue-colored saline into the left humerus

Results

On all sides [6], fluid was easily infused into the humerus. No specimen was found to have leakage from the drill hole site or into the extravascular soft tissues. All 150 cc was infused into all limbs. With dissection of the axillary vein and its tributaries, all sides were found to have engorgement of the circumflex humeral vessels draining the nutrient veins. In addition, the axillary vein was infused with blue-colored saline. For part two of the study, no tension was placed on the distal shunt tubing with full range of motion of the shoulder and no distal tubing within the humerus was removed with range of motion.

Discussion

CSF diversion has been the mainstay for the management of hydrocephalus by neurosurgeons since the early twentieth century. Ventriculoperitoneal shunting is still the preferred method to divert CSF, and while the procedure and



Fig. 4 Shunt tubing passed from a supraclavicular incision to the drill hole site of the humerus

perioperative management have improved over the years to prevent and minimize complications, it is still associated with complications such as infection, blockage, over drainage, and tube disconnection. Up to 29% of patients will have some kind of shunt complication typically within the first year of life, while 59% will require a shunt revision some time during their lifetime. When a ventriculoperitoneal shunt is contraindicated due to abdominal adhesions or abdominal infection, the surgeon must choose another site for the distal insertion of the shunt. Alternate sites that have been used in the past include the pleural cavity and the right atrium. Historically, other sites have also been suggested including the fallopian tubes, gallbladder, thoracic duct, and parotid duct; however, more recently, bone has been proposed as an alternative receptacle for CSF diversion. Recent studies and clinical use have used the sternum, the diploic space, and the ilium [2, 5, 8, 10, 12, 13, 16, 17, 25, 27, 28].

In a previous study [24], we demonstrated that the ilium could be used for IO infusion of fluid and could serve as a potential site of CSF diversion. Also, as the sternum had also been used for IO infusion [21], we also studied and demonstrated the ability of the sternum to handle large volumes (30 L) of infused water over 60 min in human cadavers and that infusion of water into this bone of live rhesus monkeys and pigs was practical [23].

AS CSF is produced at a rate of 0.37 mL/min and is replaced on average about four times per day [18], the use of these bony sites in humans seems reasonable. Since this cadaver and animal study, this technique has been used clinically [13]. Therefore, as some [19] have opined that the humeral head might be used for IO infusion of fluids, the current study was performed and demonstrated the feasibility of such a diversionary site in humans.

Complications

While many complications have been reported in the literature associated with intraosseous access, these complications only occur in less than 1% of cases [1, 4, 11, 15, 20, 26, 29]. Complications that have been reported include growth plate disruptions, osteomyelitis, hematomas, compartment syndrome, neurovascular injuries, tissue necrosis, iatrogenic bone fracture, fat embolisms, and catheter dislodgements [17]. Additional complications as noted by one study suggest that pain was the second most common complaint of acute proximal humerus IO access. The pain was more associated with the initial insertion; however, patients that were obtunded or under sedation had variable degrees of pain. Pain was associated not only with insertion of the IO, but with fluid infusion, but interestingly, when asked to compare pain associated with the proximal humerus IO versus a Foley catheter, they claimed the Foley catheter insertion pain was worse [17].

Conclusions

Based on our study, the humerus is another option available to the neurosurgeon for CSF diversion. However, animal studies and clinical use will first be necessary before the efficacy of this technique can be elucidated.

Compliance with ethical standards

As a cadaveric study, our institution does not require IRB approval. However, ethical considerations were in accord with the Declaration of Helsinki.

Conflict of interest The authors have no conflicts of interest.

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