Journal of Clinical Neuroscience 27 (2016) 53–58

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Minimally invasive evacuation of intraventricular hemorrhage with the Apollo vibration/suction device

Lee A. Tan [a], Demetrius K. Lopes [a], Lorenzo F. Munoz [a], Yojan Shah [a], Sudeep Bhabad [b], Miral Jhaveri [b], Roham Moftakhar [a,*]

[a] Department of Neurosurgery, Rush University Medical Center, 1725 W. Harrison Street, #855, Chicago, IL 60612, USA
[b] Department of Neuroradiology, Rush University Medical Center, Chicago, IL, USA

ARTICLE INFO

Article history:
Received 1 May 2015
Accepted 17 August 2015

Keywords:
Apollo
Endoscopic
Graeb score
Intraventricular hemorrhage
Minimally invasive
Modified Graeb score

ABSTRACT

Intraventricular hemorrhages (IVH) can occur as a consequence of spontaneous intracerebral hemorrhage, aneurysm rupture, arteriovenous malformation hemorrhage, trauma, or coagulopathy. IVH is a known risk factor for poor clinical outcome with up to 80% mortality. The current standard treatment strategy for IVH consists of the placement of an external ventricular drain. We report our early experience with using the Apollo suction/vibration aspiration system (Penumbra, Alameda, CA, USA) for minimally invasive evacuation of IVH with a review of the pertinent literature. Medical records of patients with IVH who were admitted to Rush University Medical Center, USA, from July to November 2014 were queried from the electronic database. Patients with Graeb Scores (GS) >6 were selected for minimally invasive IVH evacuation with the Apollo aspiration system. Patient demographics, pre- and post-operative GS, pre- and post-operative modified Graeb Score (mGS), as well procedure related complications were analyzed and recorded. A total of eight patients (five men) were identified during the study period. The average age was 55.5 years. The mean GS was 9.6 pre-operatively and decreased to 4.9 post-operatively ($p = 0.0002$). The mean mGS was 22.9 pre-operatively and decreased to 11.4 post-operatively ($p = 0.0001$). Most of the IVH reduction occurred in the frontal horn and atrium of the lateral ventricle, as well the third ventricle. One (1/8) procedure-related complication occurred consisted of a tract hemorrhage. The Apollo system can be used for minimally invasive IVH evacuation to achieve significant blood clot volume reduction with minimal procedure-related complication.

1. Introduction

Intraventricular hemorrhage (IVH) is a condition frequently encountered by neurosurgeons as a consequence of spontaneous intracerebral hemorrhage (ICH), aneurysm rupture, arteriovenous malformation hemorrhage, head trauma or coagulation disorders [1]. IVH is a known risk factor for poor clinical outcome with up to 80% mortality reported in the literature [1–4]. Clinical consequences of IVH include the development of acute and chronic hydrocephalus, elevated intracranial pressure from mass effect of the intraventricular blood clot, as well as the toxic/inflammatory effects of the blood breakdown products [1]. The current standard treatment strategy usually consists of external ventricular drain (EVD) placement and the intraventricular blood clot is often left to resolve on its own. Although EVD insertion provides cerebrospinal fluid (CSF) diversion and decreases mortality associated with acute hydrocephalus, the morbidity associated with IVH remains high despite CSF diversion and best medical management. The poor long-term prognosis with IVH has prompted clinicians to investigate other IVH treatment strategies in the hope to improve clinical outcome [1–3,5,6].

The Apollo system by Penumbra (Alameda, CA, USA) is a suction/vibration and irrigation device that was approved by the USA Food and Drug Administration in early 2014 for "controlled aspiration of tissue and/or fluids during surgery of the ventricular system." The system includes a disposable wand that is attached to flexible tubing, which is then connected to the main unit that provides suction, irrigation and vibration (Fig. 1). The wand can be inserted into the working port of a neuro-endoscope for blood clot removal in the ventricular system. The wand features a vibrating tip that breaks up the blood clot as it is aspirated into the tip, in

* Corresponding author. Tel.: +1 312 942 6644; fax: +1 312 942 5549.
E-mail address: roham.moftakhar@gmail.com (R. Moftakhar).

http://dx.doi.org/10.1016/j.jocn.2015.08.037
0967-5868/

Fig. 1. An illustration demonstrating the Apollo system setup. (Permission obtained from Penumbra, Alameda, CA, USA.)

which prevents clogging and facilitates continuous aspiration (Fig. 2).

We report our early, single-center experience with using the Apollo system for minimally invasive mechanical IVH removal in eight consecutive patients with a review of the pertinent literature.

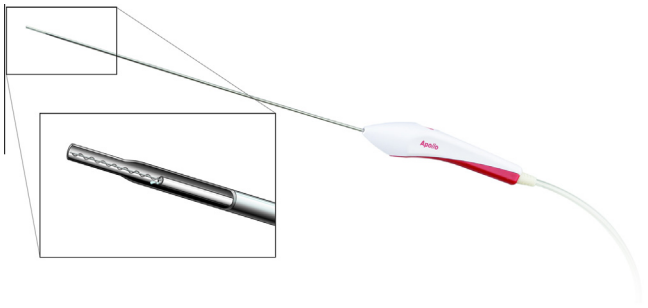

Fig. 2. An illustration showing the design of the wand, which includes a vibrating tip that can break up blood clot to prevent clogging and facilitate aspiration. (Permission obtained from Penumbra, Alameda, CA, USA.)

2. Methods

2.1. Data collection and analysis

Medical records of patients with IVH who were admitted to Rush University Medical Center, USA, from July to November 2014 were queried from the electronic database. The IVH volume was graded using both the Graeb Score (GS; Table 1) and the modified Graeb Score (mGS; Table 2) as described previously [6,7]. Patients with GS >6 were selected for minimally invasive IVH evacuation with the Apollo aspiration system, given that GS >6 was associated with worse short-term clinical outcomes [8]. Patient demographics, pre- and post-operative GS and mGS, as well as procedure-related complications were analyzed and recorded. The GS and mGS were graded before and after the Apollo procedure by an independent blinded neuroradiologist. Statistical analysis comparing the pre- and post-operative GS and mGS was performed using Student's t-test.

2.2. Surgical technique

Patients with IVH and GS >6 were selected for minimally invasive IVH evacuation with the Apollo system. The patient selection criteria was based on literature indicating that patients with GS >6 tend to have worse clinical outcomes [8]. EVD were placed on admission in the usual manner if clinically indicated. A stereotactic CT scan was then obtained for neuro-navigation to guide IVH removal. This CT scan was also used to ensure that the size of the IVH had not increased in size from the initial CT scan. In addition, every patient had a vascular imaging (CT angiogram, MR angiogram or cerebral angiogram) before the Apollo surgical procedure to ensure that the IVH was not from an aneurysm or a vascular malformation. All patients were taken to the operating room within 48 hours of initial presentation. The Apollo procedures were performed under general anesthesia. The patients were placed supine with the head in the neutral position in a Mayfield head clamp. The Stealth neuro-navigation system (Medtronic, Minneapolis, MN, USA) was then registered in the usual manner. Either unilateral or bilateral evacuation was planned depending on the location of IVH. Bilateral IVH was evacuated through two separate incisions and burr holes on each side.

A small linear incision was made in the frontal region near Kocher's point. A burr hole was created and a 19 French introducer peel-away sheath (Aesculap, Center Valley, PA, USA) was inserted with neuro-navigation to access the ventricle. The neuro-endoscope (Storz, Tuttlingen, Germany) was then passed into the sheath for visualization of the ventricular system and the blood clots. Neuro-navigation can be used as needed to confirm location of the endoscope if direct visualization is limited by IVH.