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Evacuation of intracerebral hemorrhages by neuroendoscopy with transparent sheath. Experimental study

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ABSTRACT

Objectives: Endoscopic evacuation of intracerebral hemorrhage (ICH) has been developed in order to reduce the tissue injury that conventional craniotomy could generate. Experimental studies are important to assess the effectiveness of the technique and its modifications. The objectives of this study are to develop in pig an experimental model of endoscopic evacuation of ICHs, to assess effectiveness of surgical evacuation, and to evaluate a new transparent sheath as complement to the endoscopy. Methods: Autologous blood was infused into the frontal lobe white matter in 16 pigs. In the problem group, endoscopic evacuation was performed with the aid of a new transparent sheath, which has outer and inner sheaths with blunt and closed finals. Pigs were sacrificed at 4 h, 24 h and 5 days. The volumes of hematoma and histopathological features were determined. Results: Residual volume of the problem group was significantly 70.09% lower than in control group, without significant differences in injected volumes, in percentage of subarachnoid hemorrhage, and in time interval from hematoma induction to pig´s death. The vital reaction after hemorrhage was similar in both groups. Conclusions: The experimental model developed is useful to assess endoscopic evacuation of ICHs. The endoscopy is an effective technique in the treatment of ICHs, without increasing the vital reaction secondary to hematoma. The new transparent sheath increases the visualization of surgical field and allows a continuous visual control since the beginning of the procedure. Its closed final prevents unwanted injury of the brain by the instruments used to remove the hematoma.

Introduction

The annual incidence of spontaneous intracerebral hemorrhage (ICH) is between 10 and 23 cases per 100,000 person-years [1]. ICH is characterized by high mortality and disability [2].

The main benefits of surgical intervention are to decrease the toxic effects of blood and plasma products, limit the mechanical compression of brain, decrease the intracranial hypertension, and prevent hematoma expansion [3–5]. However, surgery has not demonstrated significant clinical benefit along several prospective randomized controlled trials [4,6–11].

Conventional craniotomy is frequently associated with additional brain tissue injury. In order to reduce this tissue damage, minimally invasive techniques, such as endoscopic evacuation and stereotactic aspiration with fibrinolysis, have been developed [11].

Experimental studies are very important to assess the effectiveness of the technique and its modifications. Although the pig has been chosen as an experimental model to generate ICHs, we have not found in the literature studies about endoscopic evacuation of ICHs using the pig as experimental animal.

The objectives of this study were to develop in the pig an experimental model of endoscopic evacuation of ICHs; assess effectiveness of evacuation surgical of ICHs; and evaluate a new transparent sheath manufactured by our team as complement to the endoscopy.

Methods

Animal preparation

This study was approved by the Committee for Animal Research of the University of Salamanca, Spain. Sixteen pigs weighing 17 and 55 kg were used. Twelve hours before the start of the experiments the animals were fasted, with only water provided ad libitum.

The pigs were sedated using intramuscular diazepam (1 mg/kg), atropine (0.05 mg/kg) and ketamine (20 mg/kg). Following this sedation, a dorsal ear vein was cannulated, through which intravenous anesthetic

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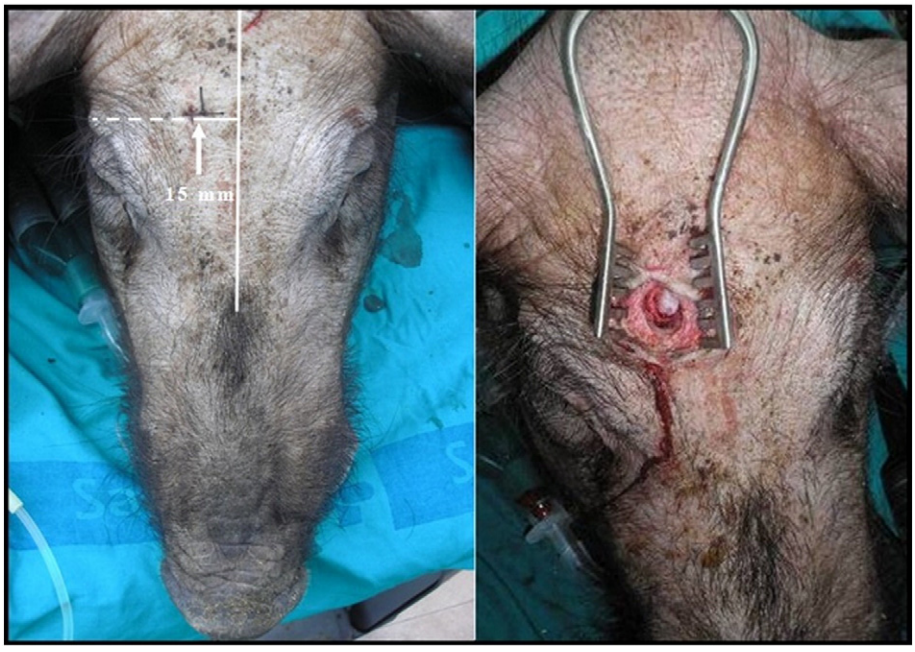

Fig. 1. Photographs showing the localization of the burr-hole. On the left one, the used coordinates are represented: 15 mm to the right of midline and in projection line of lateral eye epicanthus. On the right one, the performed burr-hole is shown, with the dura mater at the bottom.

drugs were administrated. For anesthetic induction, an intravenous bolus of propofol (2 mg/kg) was employed. The trachea of each animal was intubated. Then, the pigs were connected to a ventilator (K-Takaoka 1.04; K Takaoka Ind e Com, Sao Paulo, Brazil) and the following parameters were established: tidal volume, 8 ml/kg; inspiration–expiration rate 1:2; respiratory rate, 12 per minute; maximum pressure, 20 cm H_2O; and inspiration pressure, 1 cm H_2O. Maintenance of anesthesia was provided by intravenous propofol (10 ml/kg/h). Furthermore, experimental animals received intravenous fentanyl (2 g/kg/h) and intravenous mivacurium chloride (1 mg/kg/h). Thereafter, in the inguinal region, a femoral artery was cannulated to draw blood to induce ICH.

ICH model

All surgical procedures were performed under aseptic conditions. A cranial burr hole (14 mm) was drilled 15 mm to the right of midline and in projection line of lateral eye epicanthus (Fig. 1). Then, between 7 and 15 cc of blood was extracted from femoral artery and was injected through 20-gauge plastic catheter into the right frontal lobe, to a depth of two centimeters.

Two experimental groups were established: control and problem. Six pigs, in which evacuation was not performed, constituted the control group, while ten pigs, in which endoscopic evacuation was performed, constituted the problem group. Pigs were sacrificed at 4 h (6 animals), 24 h (n = 6) and five days (n = 4) after ICH induction by increasing the dose of propofol and administering potassium chloride.

Endoscopic evacuation. Instrumentation and surgical technique

In pigs that were sacrificed at 4 h, evacuation was performed at 2 h after blood infusion, while in the other pigs evacuation was performed at 12 h.

To endoscopic evacuation, we used a 30° rigid endoscope with an outer diameter of 4 mm and 180 mm in length (Hopkins II, Karl Storz GmbH & Co, Tuttlingen, Germany). An 18-gauge metal catheter attached to a vacuum system was used to aspirate the hematoma.

We developed a transparent glass sheath (outer sheath) that has 100 mm in length and outer and inner diameters of 10 mm and 8 mm, respectively. The end of this sheath is blunt and closed. Furthermore, the sheath has a lateral perforation to allow passage of aspirated hematoma (Fig. 2).

Other sheath (inner sheath) was developed to serve as a corridor for the endoscope. Its length is 110 mm and its outer and inner diameters are 6 mm and 5 mm, respectively. The end of the sheath is blunt closed, too (Fig. 2). Inner sheath (along with endoscope) is introduced into outer sheath. The corridor between these sheaths is used to introduce suction catheter (Fig. 3).

Through the burr hole, outer sheath was inserted. Then, inner sheath and endoscope were introduced into outer sheath. The entire system was advanced, seeing the border between normal brain and hematoma. Rotating outer sheath, lateral perforation was settled in the chosen suction area, and the hematoma was removed from depth to surface with suction catheter (Fig. 4). The direction and depth of the endoscope were changed many times to inspect all angles of the hematoma cavity, searching residues of hematoma. Hemostasis methods were not necessary.

Histophatological examination

Pigs were sacrificed by administration of intravenous potassium chloride. Intact brains were removed and were fixed in 2% formalin for 7 days (Fig. 5). The formalin-fixed brains were cut into 5-mm-thick coronal slices using a bandsaw (Fig. 6). For estimate of the approximate residual hematoma volume, the following formula was used: long diameter (A) × short diameter (B) × number of coronal brain slices with hemorrhage × slice thickness (C); this product was divided by 2 [12]. The three diameters were measured using the millimeter scale and the residual volume was measured in cubic millimeters.

Brain slices containing hematoma were embedded in paraffin, cut into 5-μm slices, and stained with hematoxylin and eosin (H & E). Histopathological changes and cell morphology and typology were studied.

Statistical analysis

The continuous variables were presented as means, medians, and range, with minimum and maximum. Furthermore, residual volumes