ORIGINAL ARTICLE

EVACUATION OF INTRACEREBRAL HEMATOMAS BY NEUROENDOSCOPY: RESULTS IN A SERIES OF CASES

Evacuación de hematomas intracerebrales mediante Neuroendoscopía: Resultados en una serie de casos

JERSON FLORES C.[1]

[1]*Department of Neurosurgery of the Guillermo Almenara National Hospital. Lima Perú.*

RESUMEN

Objetivos: La hemorragia intracerebral (HIC) e intraventricular (HIV) causan una severa morbilidad y una alta tasa de mortalidad. La hipertensión endocraneal y la lesión secundaria en la región del perihematoma están asociados a un mal pronóstico, por lo que la evacuación quirúrgica precoz con el mínimo daño al tejido cerebral es fundamental. La evacuación endoscópica utilizando un sistema Endoport es una técnica prometedora. El objetivo del estudio es presentar los resultados de la evacuación endoscópica de HIC y HIV en pacientes operados del 2010-2019 en el Hospital Almenara en Lima-Perú.
Métodos: Estudio descriptivo prospectivo, en un período de 10 años 48 pacientes con hemorragia intracerebral e intraventricular fueron sometidos a evacuación endoscópica en las primeras 72 horas, utilizando un canal de trabajo transparente (Endoport) diseñado a partir de una jeringa de 3cc. La evaluación postoperatoria fue hecha con tomografía y el seguimiento neurológico utilizando la Escala de Coma de Glasgow.
Resultados: De un total de 48 casos, 30 fueron HIC y 18 fueron HIV. La etiología más frecuente fue la HTA (75%), seguido por la malformación arteriovenosa (19%) y aneurisma cerebral (6%). La localización más frecuente fueron los núcleos basales a nivel putaminal (29%) y la región talámica (29%), seguido por la región subcortical (17%) y fosa posterior (6%). La tasa de evacuación fue del 90% en los HIC y del 80% en las HIV. No se presentaron complicaciones intraoperatorias y la complicación postoperatoria más frecuente fue la neumonía intrahospitalaria (37%). El tiempo promedio del drenaje externo en las HIV fue de 7.6 días. Todos los pacientes presentaron mejoría en la Escala de Glasgow de un promedio de 4 puntos (8.8 en el preoperatorio a 13.0 en el postoperatorio). La mortalidad global fue de 19% (20% en la HIC y 16.7% en la HIV)
Conclusiones: La evacuación endoscópica de un hematoma intracraneal, es una técnica efectiva, mínimamente invasiva y factible de llevar a cabo. Una jeringa de 3cc modificada puede ser utilizada como canal de trabajo. Esta provee suficiente espacio para una adecuada visualización del hematoma, así como para el control de un sangrado intraoperatorio.

Palabras Clave: *Hemorragia Cerebral, Hematoma, Endoscopía, Jeringas, Hipertensión Intracraneal (fuente: DeCS Bireme)*

ABSTRACT

Objectives: Intracerebral (ICH) and intraventricular (IVH) hemorrhage cause severe morbidity and a high mortality rate. Intracranial hypertension and secondary injury in the perihematomal region are associated with a poor prognosis, so early surgical evacuation with minimal damage to brain tissue is essential. Endoscopic evacuation using an Endoport system is a promising technique. The objective of the study is to present the results of the endoscopic evacuation of ICH and IVH in patients operated from 2010-2019 at the Almenara Hospital in Lima-Peru.
Methods: Prospective descriptive study, in a period of 10 years, 48 patients with ICH and IVH underwent endoscopic evacuation in the first 72 hours, using a transparent working channel (Endoport) designed from a 3cc syringe. Postoperative evaluation was done with tomography and neurological follow-up using the Glasgow Coma Scale.
Results: Of a total of 48 cases, 30 were ICH, and 18 were IVH. The most frequent etiology was hypertension (75%), followed by an arteriovenous malformation (19%) and cerebral aneurysm (6%). The most frequent location was the basal nuclei at the putaminal level (29%) and the thalamic region (29%), followed by the subcortical region (17%) and posterior fossa (6%). The evacuation rate was 90% in ICH and 80% in IVH. There were no intraoperative complications, and the most frequent postoperative complication was in-hospital pneumonia (37%). The average time of external drainage in the IVH was 7.6 days. All patients showed improvement in the Glasgow Scale of an average of 4 points (8.8 in the preoperative period to 13.0 in the postoperative period). Overall mortality was 19% (20% in ICH and 16.7% in IVH)
Conclusions: The endoscopic evacuation of an intracranial hematoma is an effective, minimally invasive, and feasible technique to carry out. A modified 3cc syringe can be used as a working channel. This provides enough space for adequate visualization of the hematoma, as well as for the control of intraoperative bleeding.

Keywords*: Cerebral Hemorrhage, Hematoma, Endoscopy, Syringes, Intracranial Hypertension. (source: MeSH NLM)*

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Intracerebral hemorrhage (ICH) is the second most common cause of stroke and has a high mortality and morbidity rate.[1] Thus, the average mortality rate at 30 days after ICH varies between 15% and 50%. [2, 3] and only 20% of patients achieve functional independence 3 months after the stroke.[4]

In the case of intraventricular hemorrhage (IVH), the consequences are even worse since the mortality rate varies from 50 to 80% in the absence of a specific treatment. [5]

This high morbidity and mortality in ICH and IVH are related to 3 main factors: Increased intracranial pressure, secondary damage caused by the direct effect of blood on the surrounding tissue,[6] and secondary hydrocephalus in the case of associated HIV; therefore, evacuating the hematoma is a fundamental measure to reduce the complications derived from this terrible disease.

Classically, the evacuation of an intracerebral hematoma has been carried out by means of a craniotomy. However, the effectiveness of this surgery has been repeatedly evaluated[7,8] and its benefits are under discussion. The Surgical Intracerebral Hemorrhage Trial (STICH) indicated that patients with spontaneous supratentorial ICH did not show any overall benefit from early surgery compared to initial conservative therapy.[7] A recent report based on the STICH II trial reported that only patients with a 10-13 GCS or large ICH would likely benefit from surgery.[9] However, the STICH and STICH II trials did not show an overall comprehensive benefit for functional prognosis over medical therapy. [10]

The ineffectiveness of craniotomy in the clinical improvement of patients with ICH could be due to the invasiveness of the technique, which implies greater manipulation of healthy brain tissue. For this reason, minimally invasive techniques such as the endoscopic evacuation of a hematoma [11,12] and stereotactic-guided aspiration with the help of thrombolysis [13, 14] have also been reported in recent years.

Endoscopic evacuation of hematomas has become a popular practice as it reduces operative time and invasiveness, and potentially improves outcomes.10 Compared to the stereotactic evacuation of ICH, hemostasis during surgery can be easily achieved with a coagulator.[15] In addition, the endoscopic procedure is less invasive than craniotomy and can be performed in some cases with the patient under local anesthesia. [15]

The present study aims to show our experience in the endoscopic evacuation of intracerebral hematomas and intraventricular hemorrhage in patients operated on in our Hospital between October 2010 and September 2019.

METHODS

A prospective descriptive study was carried out. From October 2010 to September 2019, 48 patients with intracranial hemorrhage were operated on, of which 30 were intracerebral hematomas (ICH) and 18 were intraventricular hemorrhages (IVH). The surgeries were performed by the author, using the type of surgery: Trepanation + Endoscopic evacuation of intracranial hematoma. Informed consent was obtained from family members in all cases.

Selection of patients

The cases were selected from patients hospitalized in the Guillermo Almenara Hospital emergency room and 1 case in a hospital in the interior of the country. The diagnosis of intracranial hematoma was made based on the findings in an emergency brain tomography without contrast *(Fig 1)*. In the event of a suspected AVM or cerebral aneurysm, a cerebral angiography scan (AngioCT) was also performed to define the location of the vascular lesion and plan the surgical approach.

The inclusion criteria were: 1. Diagnosis of ICH or IVH whose volume was between 20 and 70cc and which caused a

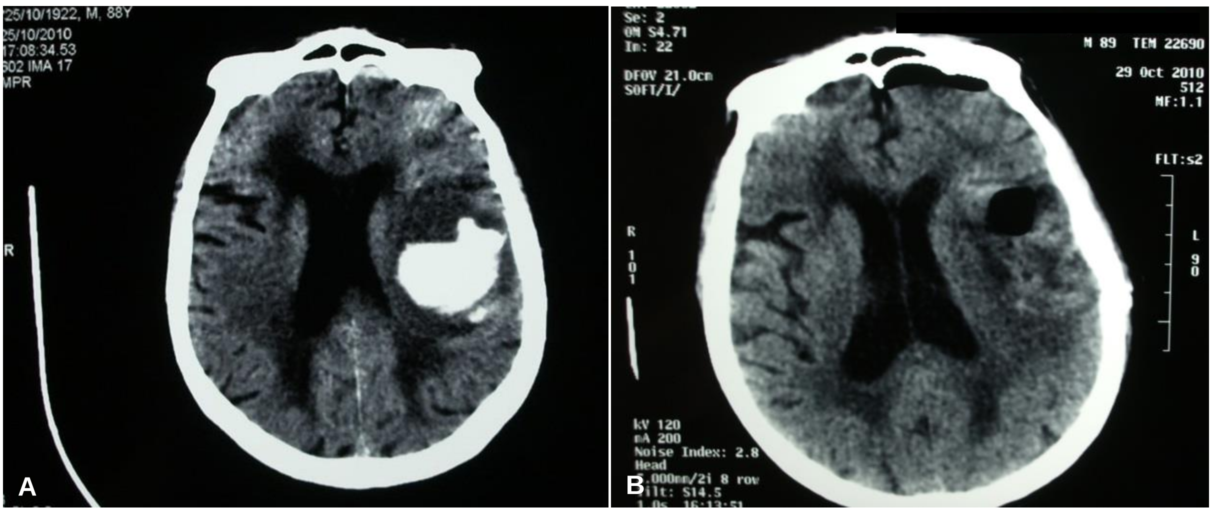

Fig 1. Endoscopic evacuation of basal ganglia hematoma in an 89-year-old patient. **(A)** Preoperative brain CT showing left subcortical intraparenchymal hemorrhage. **(B)** Postoperative brain CT on the 4th day after the endoscopic evacuation, showing the total evacuation of the intracerebral hematoma.

mass effect or hydrocephalus. 2. ICH or IVH of no more than 72 hours of evolution. The exclusion criteria were: 1. ICH or IVH, caused by tumor, trauma, or coagulopathy. 2. Treatment with antiplatelets or anticoagulants. 3 End-stage renal failure or Child C liver cirrhosis. The presence of an AVM or cerebral aneurysm was not an absolute contraindication; however, it was up to the neurosurgeon to assess the feasibility of endoscopic evacuation in selected cases and according to the need for urgent surgical treatment of intracranial hypertension.

Surgical technique

Trepanation: A linear skin incision of approx. 2.5 to 3 cm and then a manual trepanation according to the usual technique, except for making a large burr hole of approximately 1.5 cm, for which the largest bur (not commonly used) was used, to facilitate the introduction and mobility of the working channel whose diameter was 1.1 cm. The dura was opened in the shape of a cross to facilitate later coping with its edges. Care was taken to perform trepanation at the point most accessible to the hematoma; in the case of intraventricular hematomas, the entry point was like that of the placement of a ventricular shunt system (at the prefrontal level at 2 cm from the midline) and in the case of intracerebral hematomas, the entry point was located taking account of the location of the hematoma in the 3 planes (sagittal, coronal and axial) according to the measurements in the tomography.

Endoscopic evacuation: The working channel was previously manufactured from a 3cc disposable syringe, cutting the distal end of it, using the plunger as a trocar, cutting it in such a way that it is as less traumatic as possible, making in addition, lateral bevel cuts to avoid the effect of suction when removing it. Then a small cortisectomy was performed and the working channel was slowly introduced next to the trocar to a depth previously calculated in the tomography where the hematoma was found; then the trocar was slowly withdrawn with spiral movements until the remains of the hematoma were appreciated that in some cases came out spontaneously through the canal of job. The working canal was fixed manually with the help of an assistant neurosurgeon and the rigid endoscope (4mm optic, 18 cm length) was then inserted together with a long medium-caliber aspirator, and the hematoma was evacuated by means of intermittent washing and aspiration. *(Fig 2)*

In the case of an intracerebral hematoma, the clots were evacuated from the deepest to the most superficial area, taking care in addition to coagulating some bleeding vessels from the hematoma walls with the help of the suction and monopolar cannula in low voltage (10mv). The cavity was reviewed in different directions, checking for clot evacuation and adequate hemostasis. In 1 case, an intraoperative tomography was performed showing complete evacuation of the hematoma. Then, under endoscopic vision, the working canal was removed, covering some areas of the path with hemostatic material (Surgicel), no drain was left. Dura ends were faced, hemocollagene was placed, remains of previously preserved "bone sawdust", skin and soft tissues were closed in 3 planes. *(Fig 3 and 4)*

In the case of intraventricular hemorrhage, after introducing the working channel, we proceeded to identify anatomical landmarks such as choroid plexus and thalamic or septal vein, which served as a reference to guide the evacuation of the hematoma as widely as possible, both in the direction of frontal, occipital, as well as on the contralateral side, performing a fenestration of the Septum pellucidum. Finally, and after profuse irrigation with physiological saline solution, an external ventricular drainage (nasogastric tube No. 10 or 12) was left inside the ventricle under endoscopic vision; then the working channel was removed and the distal end of the drain was exteriorized by counter-opening, attached to the skin, and connected to a drainage bag (plasma transfer bag). *(Fig 5 and 6)*

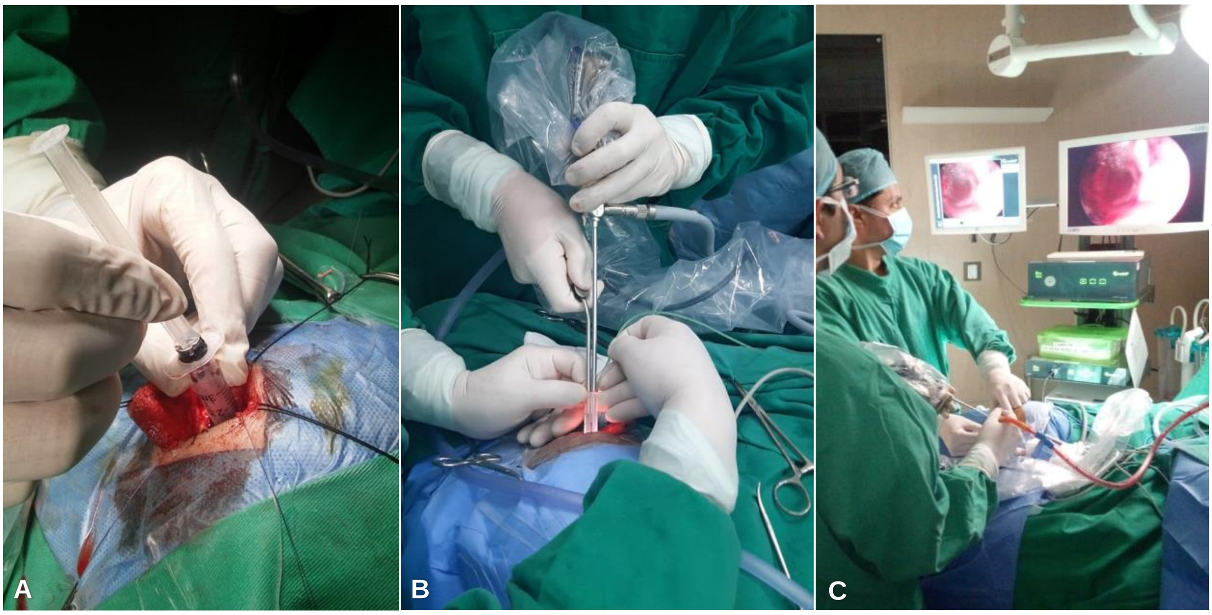

Fig 2. Intraoperative images of the endoscopic evacuation of an ICH and IVH. **(A)** Introduction of the working channel and trocar previously designed from a 3cc syringe. **(B)** Introduction of the endoscope, aspirator, and irrigation probe. **(C)** Evacuation of the hematoma under endoscopic vision (4-hand technique)

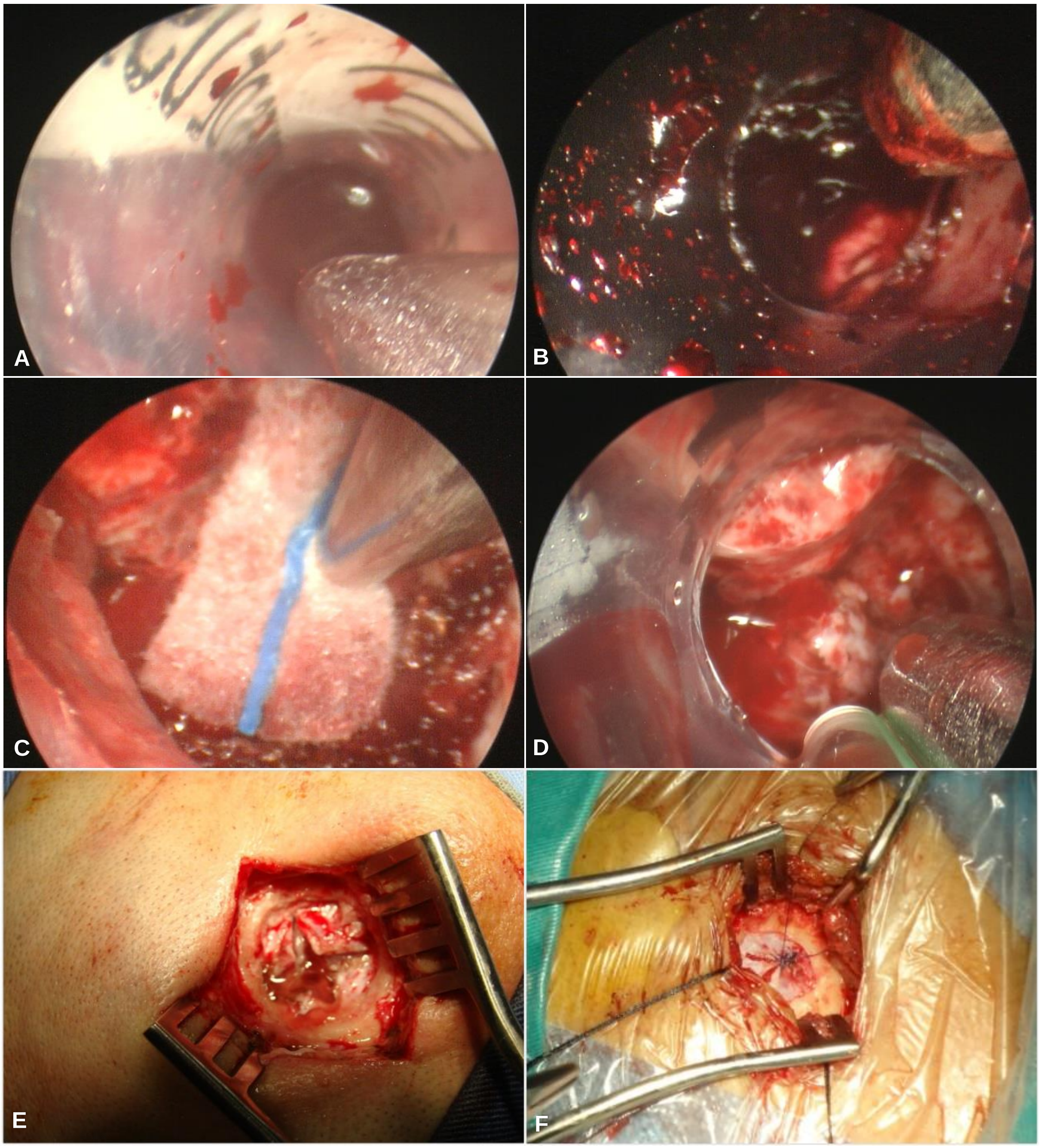

Fig 3. Intraoperative images of the endoscopic evacuation of an ICH. **(A)** Beginning of the endoscopy with the introduction of the aspirator and the endoscope through the transparent working channel. Bloody content can be seen at the distal end of the canal. **(B)** Evacuation of dense clots from the ICH. Hematoma is observed around the working canal (*dark coloration on the canal walls*). **(C)** Cottonoids and hemostatic material in the hematoma cavity allow hemostasis in a manner similar to that performed in the microsurgical technique. **(D)** Residual cavity and hematoma bed at the end of endoscopic surgery. **(E)** Trephination hole and cortical entry area at the end of surgery. **(F)** Closure of dura margins at the end of endoscopic surgery prior to skin and soft tissue closure.

Postoperative Management

In the postoperative period, the patients were hospitalized in the neurosurgical intensive care unit where they also received additional treatment for intracranial hypertension with low doses of mannitol or hypertonic solution, in addition to the treatment of other medical complications associated with the neurological status. A control tomography was performed in the first 48 hours (except in 2 cases, due to availability problems).

In the case of intraventricular hemorrhage, the external drain was removed between day 5 and day 10 of endoscopic evacuation. In all cases of suspected AVM and brain aneurysm, a brain Panangiography was performed to define the lesion. The AVM cases were treated endovascularly (embolization) during their hospitalization or later an outpatient basis. The aneurysm cases were treated by microsurgical clipping or embolization. Upon discharge, patients were referred home or to a contracted clinic to continue their rehabilitation process.

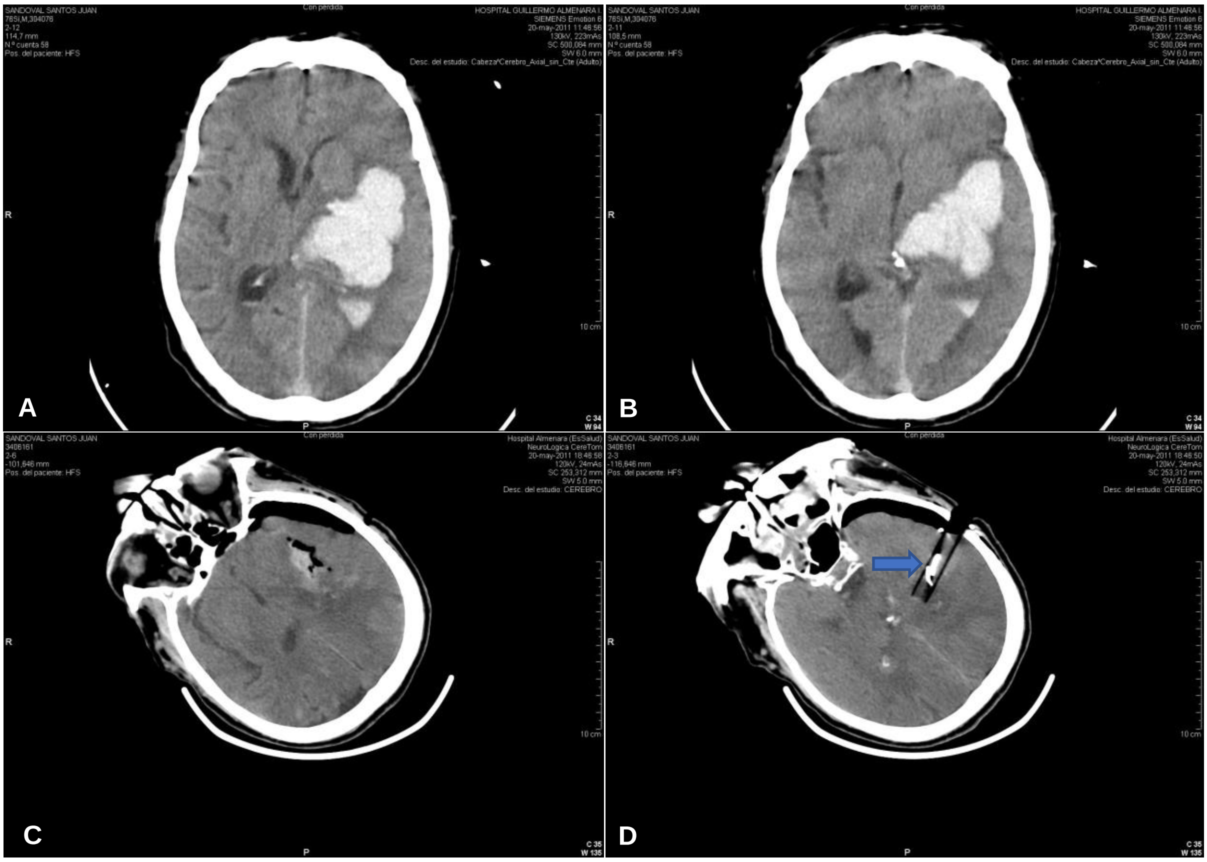

Fig 4. Endoscopic evacuation of a hemorrhage from the basal ganglia due to arterial hypertension (AHT). **(A and B)** Preoperative brain CT showing extensive left basal nucleus hemorrhage with moderate mass effect. **(C)** Intraoperative brain CT at the end of the endoscopic evacuation showing the absence of the intraparenchymal hematoma **(D)** Intraoperative CT showing the trephination hole and the working channel *(blue arrow)* with hyperdense images in its interior corresponding to cottonoids used during surgery.

Analysis of data

Data were collected prospectively during hospitalization and patients were followed up to discharge. The information obtained was grouped according to the variables: type of hematoma, evacuation rate, rebleeding rate, etiology, medical complications, mortality, location of the hematoma, Glasgow Coma Scale, and external drainage time (in the case of IVH). Statistical data are presented in averages for continuous variables, and in frequency and percentages for categorical variables.

RESULTS

From October 2010 to September 2019, 48 patients with intracranial hemorrhage were included in the study, of which 30 were intracerebral hematomas and 18 were intraventricular hemorrhages. Regarding the etiology, arterial hypertension (AHT) was the most frequent cause of intracranial hemorrhage, being present in 36 patients (75%), of which 26 cases were of intracerebral hemorrhage and 10 cases of intraventricular hemorrhage secondary to intracerebral hemorrhage. The second most frequent cause was arteriovenous malformation (AVM), which was the cause of 19% of the cases (9 patients, 4 with ICH and 5 with IVH). There were also 3 cases of IVH whose etiology was a brain aneurysm. (Table 1)

Regarding the degree of evacuation of the hematoma in cases of intracerebral hemorrhage, an almost complete evacuation of the hematoma was achieved, with the average evacuation rate of 90% of the initial volume according to the control tomography; while in the cases of intraventricular hemorrhage, the evacuation rate of the hematoma was 80%, managing to evacuate the hematoma from the frontal horns and the third ventricle, but hematoma persisted in the occipital horns. The degree of evacuation was lower in the first cases of the endoscopic evacuation of IVH due to the little initial experience, but as a greater number of cases were performed, the evacuation technique improved and a higher percentage of intraventricular hemorrhage was evacuated, especially from previously less accessible areas such as the occipital horns of both ventricles. The rebleeding rate was 0% in both groups, fortunately, there were no rebleeding cases.

Regarding complications, most of the patients with ICH (80%) evolved favorably and were discharged, some without complications and others after overcoming some infectious complications, mainly intrahospital pneumonia, which presented in 43% of the patients. cases and was more frequent in patients with low scores on the Glasgow scale. There was 1 case of cerebral infarction due to severe intracranial hypertension (ICH) that evolved unfavorably. In the IVH group, 83.3% of the patients evolved favorably,

Table No. 1: Surgical characteristics, etiology, complications and mortality of patients with intracerebral and intraventricular hemorrhage operated by endoscopic evacuation at Guillermo Almenara National Hospital, Lima Peru, 2010-2019.

	TYPE OF HEMATOMA		
	Intracerebral	**Intraventricular**	**Total**
	N	N	N (%)
Patient number	30	18	48 (100%)
Evacuation rate	90%	80%	
Rebleeding rate	0	0	0
ETIOLOGY			
HTA	26	10	36 (75%)
MAV	4	5	9 (19%)
aneurism	0	3	3 (6%)
COMPLICATIONS			
Severe edema	0	0	0 (0%)
Cerebral infarction	1	0	1 (2,1%)
Ventriculitis	0	2	2 (4,2%)
Hydrocephalus	0	2	2 (4,2%)
Hospital pneumonia	13	5	5 (37%)
mortality	6	3	9 (19%)

Source: *Database from the Department of Neurosurgery of the Guillermo Almenara National Hospital*

some after overcoming some complications such as hospital acquired pneumonia (28%), which was also the most frequent in this group, followed by ventriculitis (11%) and hydrocephalus (11%).

Overall mortality was 18.7% (9 patients) due to infectious complications such as in-hospital pneumonia and ventriculitis. Mortality in the ICH group was 20% (6 patients / 30 patients) and in the IVH group it was 16.6% (3 patients / 18 patients).

Regarding the location of the hemorrhage, the most frequent was the basal ganglia region in 18 patients (38%), followed by the thalamus in 14 patients (29%) and the subcortical region in 8 patients (17%). Likewise, the hemorrhage was purely ventricular in 5 cases (10%) and there were also 3 cases (6%) of hemorrhage in the posterior intracerebellar fossa (Fig 7). Of the cases of hemorrhage in the basal ganglia (putaminal hemorrhage), most of the cases correspond to ICH (72%), while in the cases of thalamic hemorrhage the highest percentage (57%) corresponded to thalamic hemorrhage with predominant ventricular eruption. The subcortical and posterior fossa cases were pure ICH. (Table 2)

The evolution was favorable in most of the cases, with improvement in Glasgow Coma Scale at discharge, an average of 4 points compared to preoperative. Thus, in the case of ICH, the Glasgow Coma Scale improved from an average of 9.3 at admission to 13.2 at discharge. In the IVH, the Glasgow Coma Scale improved from an average of 8.2 at admission to 12.8 at discharge. Most patients did not require a ventricular peritoneal shunt (VPS) system, the average permanence of the external ventricular drain (EVD) being 7.6 days after which it was permanently removed.

Table No. 2: Location, Glasgow Coma Scale and external drainage in patients with intracerebral and intraventricular hemorrhage operated by endoscopic evacuation at Guillermo Almenara National Hospital, Lima Peru, 2010-2019.

	TYPE OF HEMATOMA		
	Intracerebral	**Intraventricular**	**Total**
	N	N	N (%)
LOCATION			
Subcortical	8	0	8 (17%)
Putaminal	13	6	18 (38%)
Thalamic	6	8	14 (29%)
Ventricles	0	5	5 (10%)
Posterior fossa	3	0	3 (6%)
GLASGOW COMA SCALE			
At admission	9.3	8.2	8,88
At discharge	13.2	12.8	13,05
EXTERNAL DRAIN (days)	0	7.6	7,6

Source: *Database from the Department of Neurosurgery of Guillermo Almenara National Hospital.*

Patients with a diagnosis of AVM and cerebral aneurysm underwent a cerebral Panangiography to better define the lesion. All AVM cases were subsequently subjected to embolization after resolution of the brain hematoma and decreased brain edema. Of the 3 cases of IVH associated with a brain aneurysm, 2 cases (ICA and AComA aneurysms) were treated by microsurgical clipping and 1 case (AComA aneurysm) was treated by embolization presenting a favorable postoperative evolution.

DISCUSSION

Surgical evacuation of the hematoma by craniotomy and conservative therapy have been the main treatments for ICH; however, the role of surgery for most ICH patients remains controversial. In theory, surgical removal of the hematoma prevents hernia by reducing intracranial

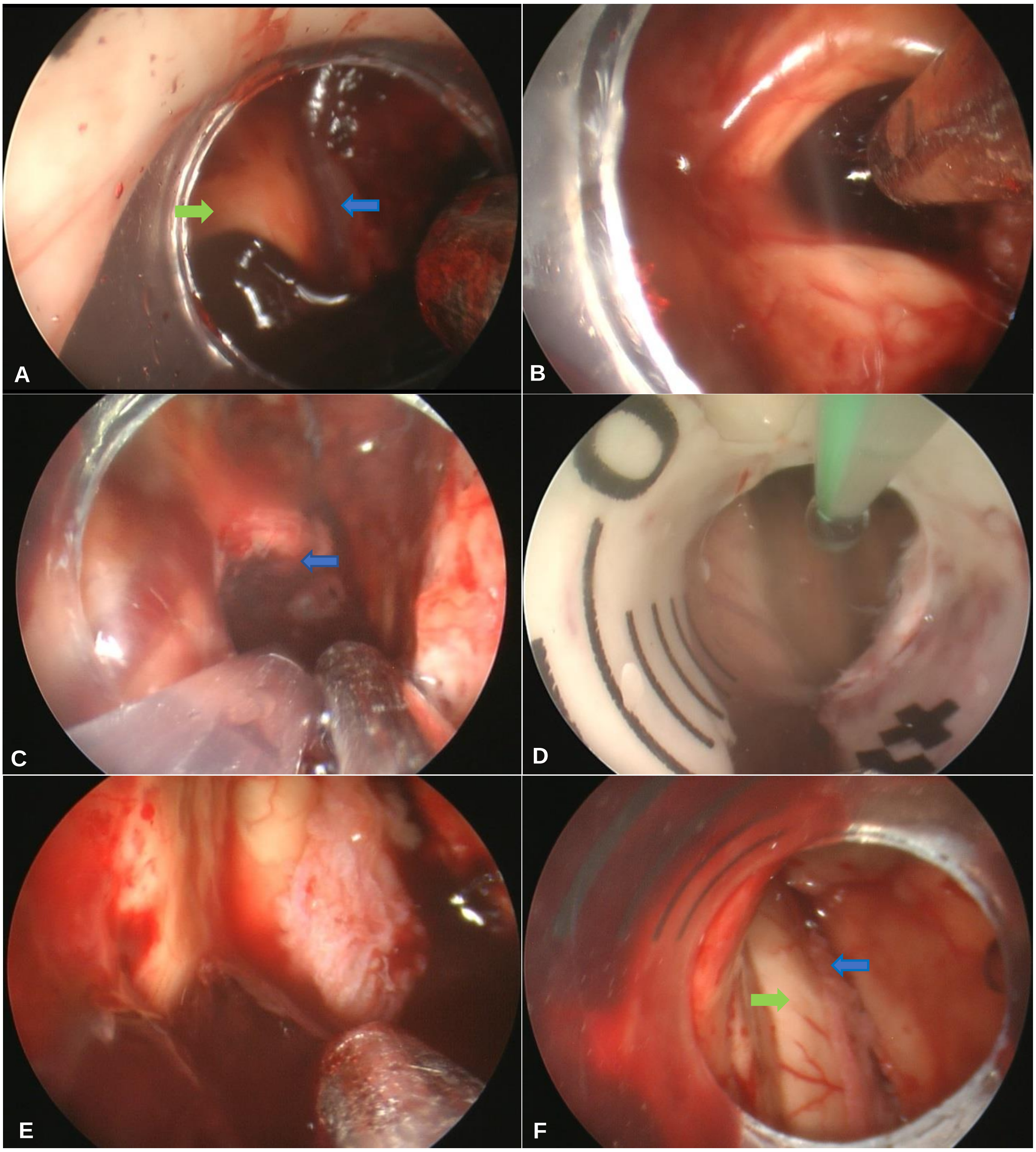

Fig 5. Intraoperative images of the endoscopic evacuation of left frontal and temporal IVH. **(A)** The evacuation of clots from the frontal horn of the left ventricle is observed where the anterior septal vein *(blue arrow)*, the fornix *(green arrow)*, and below this the foramen of Monroe covered by clots can be seen. **(B)** Evacuation of clots from the third ventricle through the foramen of Monroe. **(C)** Evacuation of clots from the wall of the left thalamus that was the source of the bleeding *(blue arrow)* by irrigation and aspiration. Part of the thalamostriate vein can be seen on the lateral side. **(D)** Left lateral ventricle at the end of endoscopic evacuation. where a nasogastric tube is appreciated inside which is left as an external ventricular drain. **(E)** Evacuation of clots from the left temporal horn where the choroid plexus previously covered by clots begins to be seen. **(F)** Posteroanterior view (with the patient in right lateral decubitus) of the temporal horn at the end of evacuation of the hematoma showing the temporal horn free of clots, the temporal choroid plexus *(blue arrow)*, and the parahippocampal region *(green arrow)*.

pressure and decreasing the pathophysiological impact of the hematoma on the surrounding tissue.[6] However, the effectiveness of the surgery has been repeatedly evaluated [7,8] and its benefits are still underway discussion.

The Surgical Intracerebral Hemorrhage Trial (STICH) indicated that patients with spontaneous supratentorial ICH did not show any overall benefit from early surgery compared to initial conservative therapy. However, the interpretation of these results is complicated because a percentage of patients (24%) in the initial conservative treatment group received surgery.[7] The STICH II trial confirmed that early surgery did not increase the rate of death or disability, 6 months postoperatively, and may have a small but clinically relevant survival advantage for patients with spontaneous superficial ICH without intraventricular hemorrhage. [8]

A recent report based primarily on the STICH II trial reported that only patients with a GCS 10-13 or large ICH

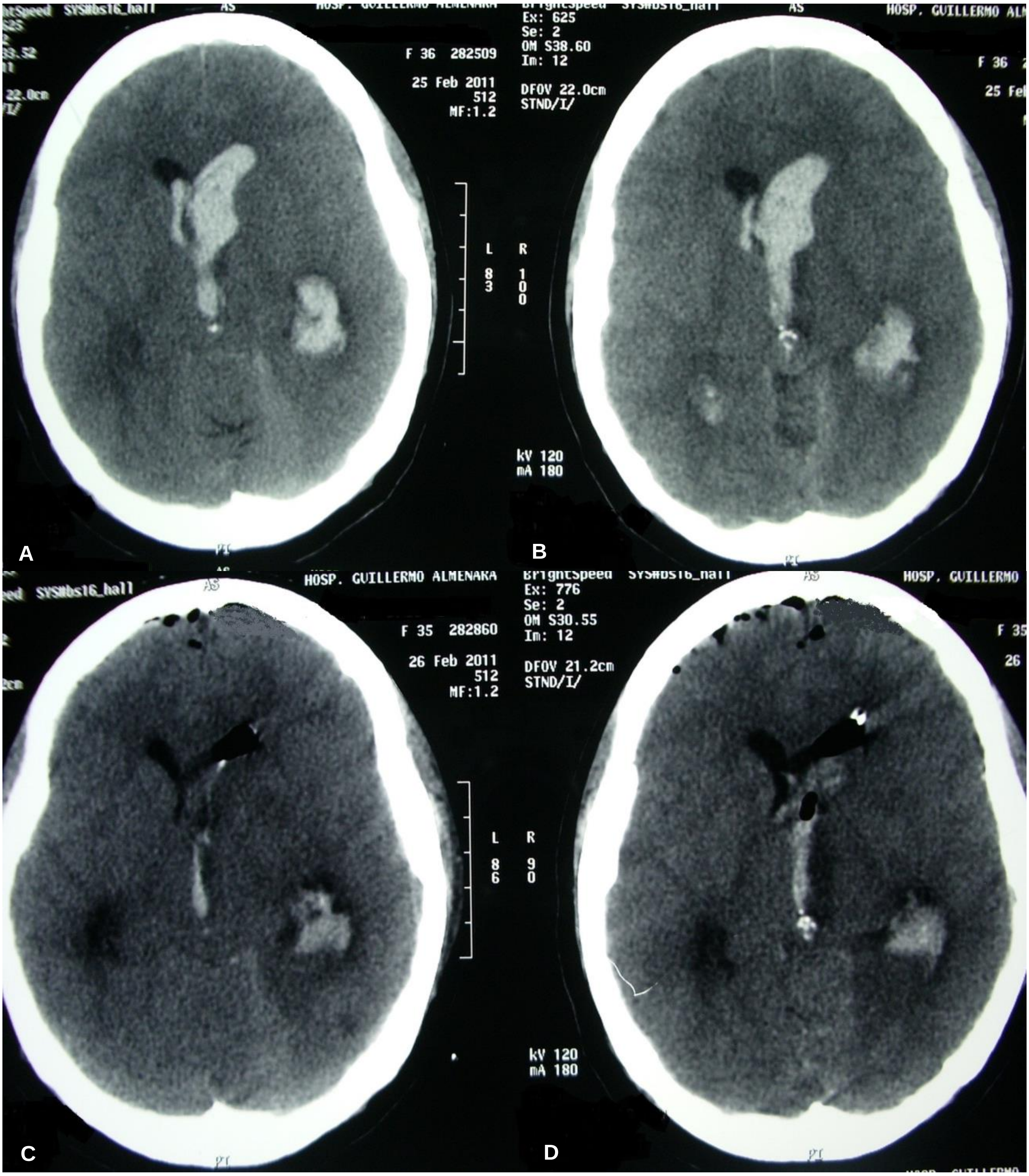

Fig 6. Endoscopic evacuation of intraventricular hemorrhage due to left temporal AVM. **(A and B)** Preoperative brain CT showing hemorrhage in the lateral ventricles (frontal and temporal horn) and in the 3rd ventricle. **(C and D)** Postoperative brain CT the day after endoscopic evacuation, showing evacuation of the hematoma from the lateral ventricles and the 3rd ventricle, as well as correction of the hydrocephalus.

would likely benefit from surgery.[9] However, the STICH and STICH II trials did not show an overall comprehensive benefit in the functional prognosis over medical therapy.10 Furthermore, in these previous studies, almost all patients underwent craniotomy, so the benefit and efficacy of minimally invasive surgery such as the endoscopic evacuation of the hematoma are unknown.

Regarding IVH, it should be mentioned that there are 2 types: Primary IVH is that which is limited to the ventricles, and secondary IVH is that which occurs due to ventricular breakthrough from ICH affecting the thalamus and basal ganglia.[16] IVH is an independent predictor of poor prognosis in patients with ICH [17]. According to the results of the STICH trial,[7,8,18] the prognosis of patients with IVH is worse than that of patients without HIV (p <0, 00001) and if IVH is associated with hydrocephalus, the prognosis will be the worst.

Classically, the only treatment for IVH has been the placement of an external ventricular drainage system (EVD) without thrombolytic agents, which is used first to help drain blood from the ventricles; however, the use of EVD alone may not effectively improve patient outcome due to the slow rate of intraventricular blood collection [19]. Multiple clinical studies have reported that intraventricular administration of thrombolytic agents may reduce mortality by accelerating lysis of the clot [20-22]. A meta-analysis of 8 observational studies and 4 randomized studies of IVH patients treated with EVD (n = 149) or EVD with fibrinolysis (n = 167) found a significant decrease in mortality from 47% to 23% (OR, 0.32; 95% CI, 0.19-0.52) [23]. For this reason, the 2015 AHA / ASA guidelines for the diagnosis and treatment of spontaneous cerebral hemorrhage 6 have suggested using an EVD plus tissue-type plasminogen activator recombinant (rtPA) in IVH patients; however, the efficacy and safety of this treatment are uncertain (Class IIb; Level of evidence B).

Endoscopic evacuation of the hematoma has become a popular practice as it reduces operative time and invasiveness, and potentially improves outcomes 10. Compared to the stereotactic evacuation of ICH, hemostasis during surgery can be easily achieved using a coagulator. [15] Furthermore, the endoscopic procedure is less invasive than craniotomy and can be performed even with the patient under local anesthesia.[15] The efficacy of endoscopic removal of hematomas has been reported in multiple studies.

In endoscopic surgery for intracerebral hematomas, using a good working channel is an important step. Many working channels such as the transparent working channel or other hand-made working channels have been developed and reported in the literature.[24-28] Thus, for example. Wei-Hsin Wang et al [29] used a craft rubber balloon catheter to create a path and then inserted a clear channel or retractor along this path. However, it is important that the construction of this path be an easy method for any neurosurgeon to perform during an emergency, safe since it should only separate the fibers and not destroy them, and ideally, it should allow the introduction of the working channel at the same time to minimize damage to the brain parenchyma. We achieve this objective with the use of a 3cc syringe, which is prepared during surgery and whose modified plunger serves as an introducer or trocar that allows the path to the hematoma, after which it is easily withdrawn leaving the canal of the 3cc syringe as a transparent channel. This channel also has the advantage of having measurement lines engraved on its surface that serve as a numerical depth reference.

In recent decades, some ICH evacuation studies using the neuroendoscope have placed great emphasis on protecting the surrounding brain regions and have shown a high evacuation rate (ranging from 83.4% to 99%) [30-32]. In our study, the evacuation rate for ICH was 90% and for IVH it was 80%. The evacuation was greater in deep and well-defined ICH, as well as in hematomas of hypertensive origin, while in ICH associated with AVM, the evacuation was lower because part of the hematoma was adhered to the AVM, thus it was necessary to avoid intraoperative rebleeding. On the other hand, the degree of evacuation was lower in IVH due to the difficulty in evacuating the hematoma from inaccessible areas such as that located in the occipital horns during access through the frontal horn. However, as more experience was achieved, it was possible to increase the evacuation percentage in IVH.

Regarding the incidence of complications, the study by Nagasaka [25] indicated that endoscopic evacuation of an ICH was associated with a minimal rebleeding rate (0% -3.3%) compared to the traditional craniotomy approach (5% -10 %). In our study, the rebleeding rate was 0%, which agrees with the rebleeding rates mentioned in the medical literature. Hemostasis is a great challenge in endoscopic hematoma surgery. Lack of familiarity with the hands-free technique and limited instruments make hemostasis more difficult than with traditional microsurgery. Although some multifunctional instruments have already been developed to overcome this limitation, a further problem is that the instruments are expensive. In our practice, we use a heavy gauge aspirator to evacuate the hematoma and a thin gauge aspirator (6Fr) to carefully aspirate a bleeding vessel so that it adheres as closely as possible to the aspirator wall and then with the help of a monopolar that contacts the aspirator at the end of the working channel, the vessel is coagulated, achieving control of bleeding. Hemostatic such as “Surgicel” are also used in a similar way to what is done during a microsurgical evacuation.

The selection of the approach (the frontal or temporal approach) for putaminal ICH is an important issue, in our study putaminal hemorrhage was the most frequent and constituted 38%. Hsieh et al. [24] mentioned that, in patients with an ICH volume less than 50 ml, it is not difficult to evacuate the hematoma due to the shorter distance from the cortical surface to the hematoma. However, when the hematoma is larger than 50 ml, the shape generally becomes elliptical. The frontal approach was recommended by the authors in these cases because it involves non-eloquent regions and provides better visualization that can result in the maximum evacuation of the hematoma. We used the temporal approach for putaminal or thalamic hematomas without ventricular invasion since it represented the shortest path to the hematoma, however, when IVH due to ventricular eruption of the hematoma was predominant, we used the frontal approach using the Kocher point as a parameter, similarly to the placement of a frontal VPS system.

This allowed us to achieve a better intraoperative stereotaxic orientation and avoid further injury to the brain parenchyma during the introduction of the working channel, even more so given the fact that there was no intraoperative imaging aid system such as a Neuronavigation or ultrasound.

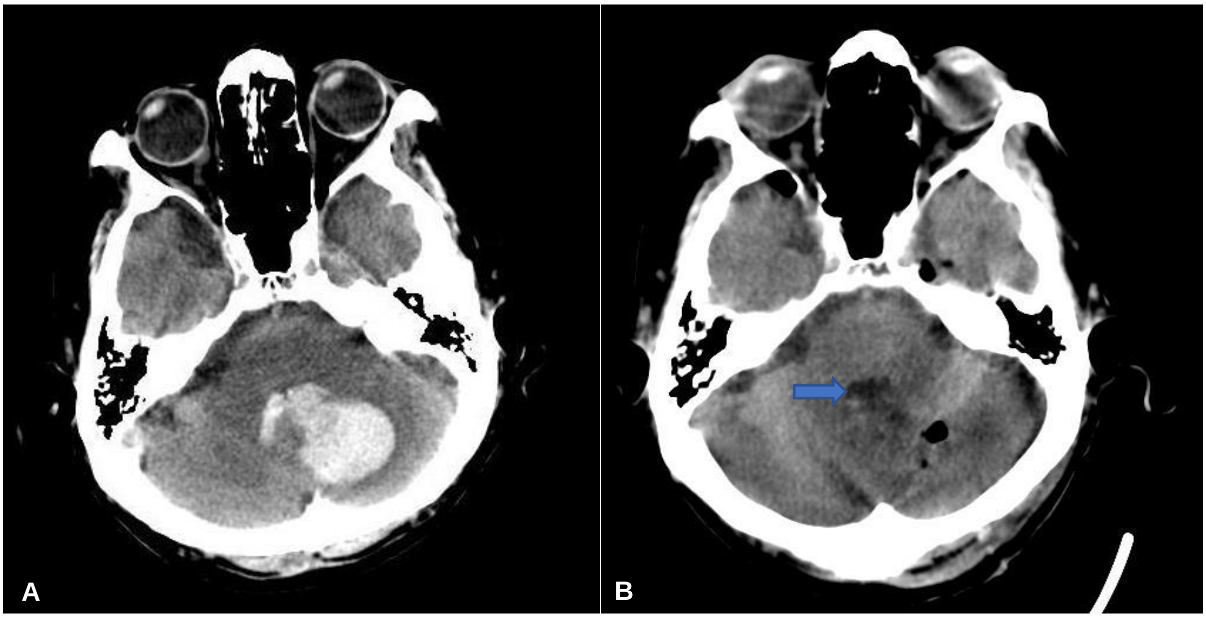

Fig 7. Endoscopic evacuation of posterior fossa hematoma. **(A)** Preoperative brain CT showing left cerebellar hemorrhage. **(B)** Postoperative brain CT on day 2 showing total evacuation of the hematoma and opening of the IV ventricle *(blue arrow)*

The mortality rate of IVH patients treated with endoscopic surgery per year varies from 10 to 30%, which is almost equivalent to the efficacy of EVD.[5, 33, 34] Our study shows a mortality rate in IVH of 22% which is comparable to the values previously mentioned. Several studies have shown that endoscopic surgery for evacuation of IVH (with EVD) has advantages over EVD alone [5,35], thus it is appreciated that the incidence of postoperative hydrocephalus and the dependence on postoperative ventriculoperitoneal bypass surgery is lower in the endoscopic group. The following factors could also be of great importance to improve patient outcomes: 1. Endoscopic surgery could remove the hematoma and improve brain perfusion rapidly, reducing extrusion effects on critical brain structures and neurotoxic effects of the products of the breakdown of the hematoma. 2. Neurosurgeons could evacuate the hematoma under direct vision, which increases the rate of removal of the hematoma and reduces the likelihood of postoperative rebleeding 3. The drainage catheter could be placed under direct view, improving the precision of placement, and avoiding damage to the choroid plexus. [36]

This study shows our initial experience in the endoscopic evacuation of hematomas and demonstrates the feasibility and efficacy of the endoscopic evacuation of ICH and IVH, however, it is important to mention some limitations of the study such as the size of the sample, the time from the hemorrhage until surgery which was a long period of 72 hours and not exclusively in the first 24 hours, the variety in the etiology of ICH and IVH, some of which were not included in other studies. Prospective studies are required with larger sample size and with more specific selection criteria, the same ones that we are currently carrying out.

CONCLUSIONS

The endoscopic evacuation of an intracerebral hematoma and an intraventricular hemorrhage a minimally invasive, safe, and effective technique. It is a relatively simple technique and feasible to perform in almost any medium-complexity hospital. It achieves high hematoma evacuation rates as well as low rebleeding rates.

The basic instruments necessary for endoscopic evacuation are accessible and consist of a transparent working channel (3cc modified syringe) used as an Endoport System, a 0º, 4mm endoscope, an aspirator, as well as a monopolar and bipolar system, all of which is easy to get in the most hospitals in our environment, without being essential to have sophisticated instrumentation. Our goal is for endoscopic evacuation to be the standard technique for endoscopic evacuation of intracerebral and intraventricular hematomas.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Authors Contributions

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Correspondence

Jerson Flores C. Department of Neurosurgery. *Guillermo Almenara National Hospital. 800 Grau* Avenue. La Victoria. Lima 13, Perú. *E-mail:* jersonmit@yahoo.es