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Endoscopic Evacuation of Spontaneous Supratentorial Intracerebral Hematoma

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Abstract: Background: Spontaneous Supratentorial Intracerebral Hematoma (SICH) is one of the most common types of stroke. It is estimated that this condition affects 10- 20 in 100 000 people every year with a mortality between 23- 58%. The decision about whether and when to surgically remove ICH remains controversial because the traditional surgical approach (craniotomy) sometimes causes further brain injury. The introduction of the neuroendoscope has brought with it the new idea of minimal invasiveness which may improve the surgical results of ICH**.** **Purpose:** To study the surgical outcome of endoscopic evacuation of spontaneous supratentorial intracerebral hematoma. **Patients and Methods:** This study was conducted in Department of Neurosurgery at Tanta University, Twenty patients underwent endoscopic evacuation of Spontaneous Supratentorial Intracerebral Hematoma. **Results:** Male constituted 70% of the patients of the study while females constituted 30% of them. The mean age of the patients was 57.75 years. 80% were hypetensive. The mean evacuation rate was 84.89 % with median GOS was 3. **Conclusion:** The future treatment of SICH should convert to the minimally invasive surgery. Endoscopic evacuation of spontaneous supratentorial ICH is becoming a standard surgical procedure and promising clinical results can be expected with a learning curve. Using the neuroendoscope can create an improved view, limit adjacent brain tissue injury, reduce bleeding, and enhance time efficiency. Therefore, being familiar with the neuroendoscope and related instrumentation is the best way to create a better result and fewer complications.

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1. Introduction

Spontaneous Supratentorial Intracerebral Hematoma (SICH) is one of the most common types of stroke. It is estimated that this condition affects 10-20 in 100 000 people every year with a mortality between 23 -58%. Early studies estimated an incidental equal to subarachnoid hemorrhage (SAH), but more recent studies in computerized tomography (CT) era show approximately twice the incidence as SAH. [1, 2]

The pathophysiology of brain injury surrounding the hematoma is due to disruption and damage of the neurons and glial cell (primary injury). The initial insult from hematoma sets off a cascade of various metabolic processes which lead to perihematoma inflammation and edema from disruption of Blood Brain Barrier (BBB). The edema leads to further mass effect increasing intracranial pressure (ICP) and causing further neurological decline (secondary injury). Heme and iron are released after red cells lyses and lead to inflammation and causing toxic effects in the surrounding brain tissue. (3, 4)

Risk factors for SICH include age, sex and race, oral anticoagulant, liver failure, alcohol consumption and I.V. drug abuse.

Causes of SICH include hypertension, bleeding disorders e.g. hemophilia, ruptured cerebral aneurysm, ruptured arteriovenous malformation, hemorrhagic tumors and amyloid angiopathy. (5, 6)

In general, the neurological deficit of SICH is characterized by a smooth progressive onset over minutes to hours. It is commonly accompanied by headache, vomiting and altered consciousness. Elevation in blood pressure occurs in as many as 90% of patients, Seizures occur in approximately 10% of patients. (7)

Computerized Tomography (CT) scanning is the initial diagnostic procedure as it is rapid, available at emergency department and not confusing. CT angiography may reveal a spot sign which associated with hematoma expansion and also very helpful in detecting vascular pathology e.g. AVMs and aneurysms. Magnetic Resonance Imaging (MRI) is helpful for identifying underlying cause as tumors but it is expensive, takes longtime, not available in most hospitals and confusing related to hematoma detection depending on hematoma onset. (8, 9)

Care should always begin with airway stabilization, breath and circulation (ABCs) so intubation is performed in patients as needed for airway protection and even mechanical ventilation may be used. Elevation of bed head 30 degree should be done. Medical therapy includes dehydrating measures to decrease increased intracranial pressure from mass effect and edema, blood pressure control, correction of coagulopathy, fever control, seizure prophylaxis, deep venous thrombosis prophylaxis, maintenance of normoglycemia, electrolyte balance and nutritional support. (10)

The decision about whether and when to surgically remove ICH remains controversial because the traditional surgical approach (craniotomy) sometimes causes further brain injury. The introduction of the neuroendoscope has brought with it the new idea of minimal invasiveness which may improve the surgical results of ICH. Early surgery to limit the mechanical compression of brain and the toxic effects of blood may limit injury leading to improve the neurological and general condition, reduces morbidity and mortality, shortens hospitalization, promotes the return to activities of the daily life and reduces medical costs. In addition, endoscopic evacuation surgery has advantage of less adjacent tissue injury, less blood loss and less operation time. (11, 12)

2. Material and Methods

This study was conducted in The Department of Neurosurgery at Tanta University, from June 2017 to June 2018. It included Twenty patients underwent endoscopic evacuation of Spontaneous Supratentorial Intracerebral Hematoma (SICH).

A) Patient population:

I. Inclusion criteria including Spontaneous supratentorial intracerebral hematoma on CT scan with mass effect or midline shift more than 0.5 cm on imaging and volume of hematomas more than 25 cm^3. Rapid deterioration in Glasgow Coma Scale (GCS) in spite of adequate medical therapy.

II. Exclusion criteria including Small hematoma ≤ 25 cm^3. Situations with little chance of good outcome as large hemorrhage in dominant hemisphere, GCS ≤ 5, loss of brain functions (e.g fixed dilated pupils).

Patients who are not fit for surgery due to significant underlying medical disorder e.g. Severe coagulopathy.

Infratentorial hematoma.

B) Preoperative protocol:

I. Personal history including; Age, Sex and Special habits e.g. smoking.

II. Past and medical history including; Hypertension, D.M., Hepatic disease, Renal disease, Asthma

III. Clinical:

1) General examination: vital signs especially blood pressure.2) Neurological examination including Glasgow Coma Scale (GCS), Motor power, Pupils.

IV. Investigation:

1) Neuroimaging including; CT brain was done as the initial radiological examination for all patients. The site of hematoma will be classified according to site and volume. Its volume will be measured according to a bedside method of measuring CT ICH volume. **The Broderick's formula** (AxBxC)/2 will be used, where A is the greatest hemorrhage diameter by CT, B is the diameter 90 degrees to A and C is the approximate number of 10 mm CT slices with hematoma.

2) Laboratory testing including coagulation profile, complete blood picture, liver and renal functions, random blood sugar and lipid profile will be done.

C) Surgical technique:

I. Preoperative preparation including;

The steps, costs, potential results and follow up methods were explained to the first degree relatives before the intervention. Control blood pressure. Administration of I.V mannitol bolus (one gram/kg), lasix (20mg), steroids (dexamethasone 4mg) for all patients preoperatively.

II. Surgical technique:

Procedure is performed in an operating room equipped with neuroendoscope while the patient lay supine and sterilization of the affected side of the cranium was done after general anaesthesia. Identification of the entery point according to the site of hematoma; Safe entry points could be (**Kocher's point** which located about 1 cm anterior to the coronal suture and 3 cm lateral to the midline at approximately the mid-pupillary line) or at **longitudinal axis of hematoma** (mostly **frontal**). A linear scalp incision (~5 cm) was then made. A 2.5-3cm burr hole was created. After tenting the dura, it was opened in a U or cruicate (1) shape. A 1-cm cortical incision with bipolar cauterization was made. Inflatable balloon inserted deflated. Its trajectory is based on the site of hematoma showed by CT Brain scanning towards the **top** of hematoma if **longitudinal axis entry point** pathway used or to the **middle** of hematoma in **Kocher entry point**. Then the balloon inflated by saline pushed gently from syringe connected to it, and the entry tract was created. A transparent plastic sheath (View Site Brain Bath System, England) was then placed through the made tract guided by the inflatable balloon. After establishing a channel, the endoscope was introduced by hand into the space that was created by the hematoma. Most hematomas may gush out due to high pressure, so we applied a 37-mm 0_ rod-lens endoscope (18 cm in length: KARL STORZ GmbH & Co. KG e Tuttlingen, Germany) to aspirate the residual hematoma.

Fig. (1) showing the brain path system consisting of transparent sheath, inflatable balloon connected to a syringe filled with saline

Fig. (2) showing a transparent plastic sheath was then placed through the made tract.

Kocher enter point:

As we said before that the trajectory towards the middle of the hematoma, the deepest part of the hematoma should be removed first, and the sheath withdrawn gradually, facilitating the pushing of the residual part of the hematoma into the tip of the sheath. Most of the time, the surgeon can hold the endoscope in one hand, and aspirate the hematoma by smooth-tip suction with the other hand. A clot that is adhesive to the hemotoma cavity should not be sucted with force. There are three methods to aspirate a hematoma in an extreme angle corner: (1) 30_ and 45_ rod-lens endoscope (2) angled suction (either anterior or posterior angled suction with a 5-mm, 7-mm, or 10-mm diameter) and (16) rotation manipulation of the sheath within the brain parenchyma.

Longitudinal axis enterypoint:

Here the trajectory towards the top of the hematoma which is evacuated from the top to bottom side. Internal decompression of the soft hematoma, which is easy to suck, is the first to be evacuated. Only the portion of the hematoma protruding into the sheath is evacuated. The next step is bordering between the hematoma and brain parenchyma. Most parts of the hematoma can be removed with meticulous spiral movement of the transparent sheath. The hard hematoma on the wall of the hematoma cavity which may be hematoma-ruptured vessel complex, should be left untouched.

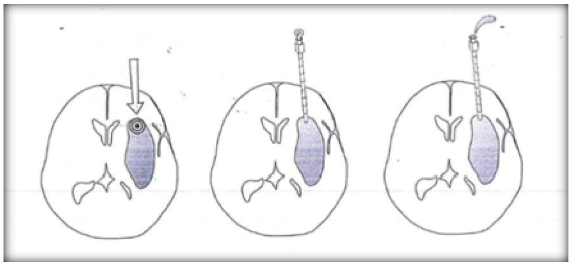

Fig. (3) showing the trajectory towards the top of the hematoma.(107)

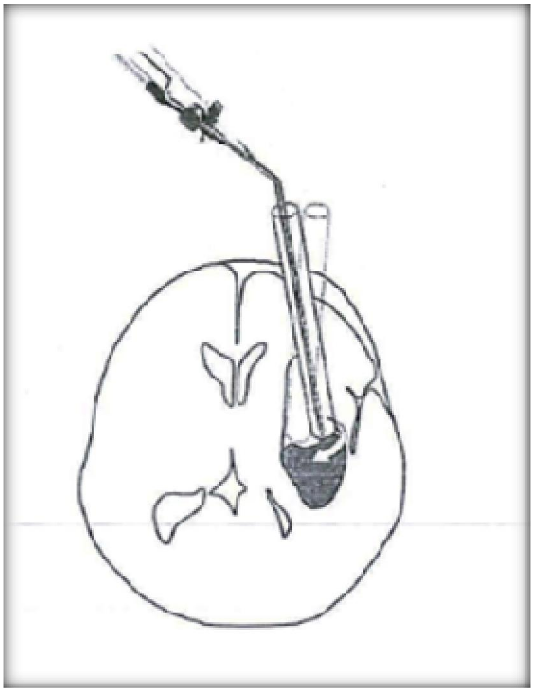

Fig. (4) showing bordering between the hematoma and brain parenchyma with meticulous spiral movement of the transparent sheath.(107)

After most of the hematoma is removed, the brain parenchyma sinks down and the hematoma cavity collapses that makes an obstacle to further evacuation of hematoma. Small hematomas may sometimes be clues to hidden large hematomas like the tip of an iceberg. Therefore, a policy for trying to achieve total removal of a hematoma may be needed.

For residual hematomas, operating under a wet field is more desired than a dry one. With inflation of the hematoma cavity, re-expanses it and further evacuation is done with sheath adjustment.

In both Entery points:

If there is only oozing without active bleeders, the oozing can be stopped with hemostatic agents. If an active bleeder needs cauterization, we may use bipolar forceps with the endoscope held by an assistant

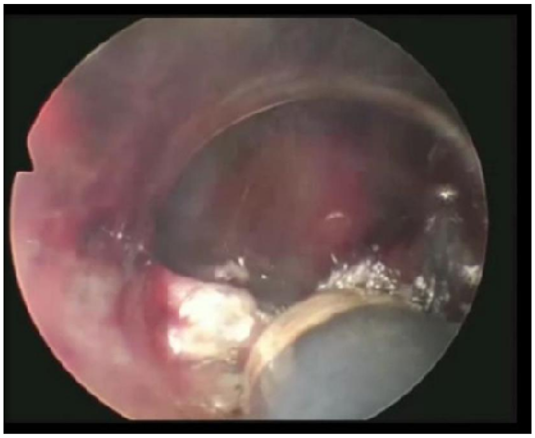

Fig. (5) Showing endoscopic view showing cautarization of a bleeder.

In our experience, hemostasis in typical hypertensive ICH can be achieved by hemostatic agents (such as Surgical Hemostatic). However, excess cauterization is not necessary and may cause neural damage. After sufficient hemostasis has be obtained, the transparent sheath is withdrawn step by step under endoscopic vision and the overall length of the surgical tract is packed with hemostatic agents. Finally, when adequate hemostasis is confirmed, all instruments are withdrawn and the dura is closed using a free galeal flap or pericranial flap. The scalp is closed in layers.

III. Postoperative:

Postoperative systolic blood pressure must be strictly controlled at <160 mmHg, and the presence of excessive fluids not allowed. Immediately after stabilizing the patient, brain CT scan was arranged for all patients undergoing hematoma evacuation. Hematoma volumes were calculated from the sum of the areas contoured on each slice, multiplied by the slice thickness (usually 5 mm). The hematoma evacuation rate was calculated and presented by percentage as: preoperative hematoma volume - postoperative hematoma volume / preoperative hematoma volume

IV. Follow up of outcome measures:

Patients will be followed up clinically and radiologically for 3 and 6 months. Clinical evaluation by neurological examination (GCS, pupil and motor power and GOS), while radiological evaluation by CT brain.

-Case presentations:

Case 1:

3. Results

Statistical analysis of the data:

Twenty patients with spontaneous supratentorial intracerebral hematoma, admitted to Neurosurgery Department- Tanta University Hospital. All patients underwent Endoscopic evacuation of SICH.

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

The used tests were

1 - Student t-test for normally distributed quantitative variables, to compare between two studied groups.

2- Paired t-test for normally distributed quantitative variables, to compare between two periods.

3- Pearson coefficient to correlate between two normally distributed quantitative variables.

4 - Mann Whitney test for abnormally distributed quantitative variables, to compare between two studied groups.

5–Wilcoxon signed ranks test for abnormally distributed quantitative variables, to compare between two periods.

6 - Spearman coefficient to correlate between two distributed abnormally quantitative variables.

Out of 20 patients constituting this study, 14 (70%) were males and 6 (30%) were females.14 (70%) were ≤60 years and 6 (30%) were >60 years.16 (80%) were hypertensive and 11 (55%) were diabetic.

The Time between ictus (1st CT brain) & surgery of patients in this study ranged from 6 to 28 hours with a mean time 13.75 hours and a median time 12 hours. The evacuation rate of ICH in this study ranged from 64 to 98 % with a mean 84.89 % and a median 89.45%. The operative time in this study ranged from 60 to 120 minutes with a mean time 86.25 minutes and a median time 82.5 minutes. The operative blood loss in this study ranged from 50 to 300 ml with a mean loss 85.75 ml and a median 67.50 ml. The postoperative ICU stay of patients in this study ranged from 1 to 14 days with a mean 7.45 days and a median 7 days. The postoperative hospital stay of patients in this study ranged from 1 to 17 days with a mean 10.65 days and a median 10 days. The GOS of patients in this study ranged from 1 to 4 with a mean 2.95 and a median 3.

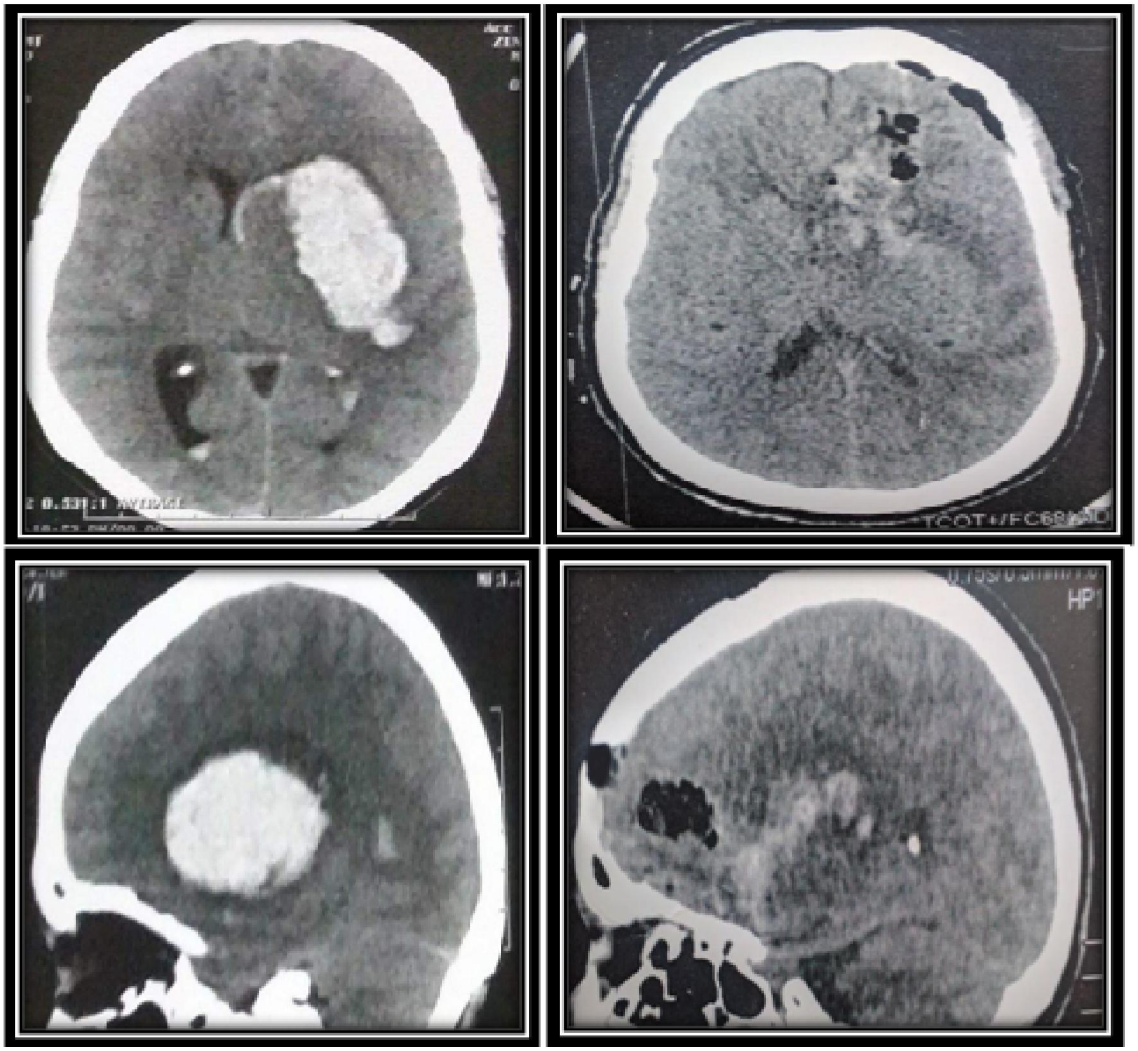

Fig. (6) showing comparison between preoperative CT brain (axial, sagital) of a female 45y. patient has left 35cc hematoma with GCS 8 and postoperative CT brain (axial, sagital) of the same patient with surgical entery point at long. axis of hematoma (Frontal burr hole). Evacuation rate was 97 %.

Table (1): Comparison between preoperative and postoperative according to hematoma volume (ml) (n= 20)

Hematoma volume	Pre	Post	Z	p
Min. – Max.	**30.0 – 65.0**	**0.50 – 22.0**	**3.923***	**<0.001***
Mean ± SD.	**43.50 ± 9.75**	**7.55 ± 7.25**		
Median	**40.0**	**4.50**		

Z: Wilcoxon signed ranks test

p: p value for comparing between pre and post

*: Statistically significant at $p \leq 0.05$

Case 2:

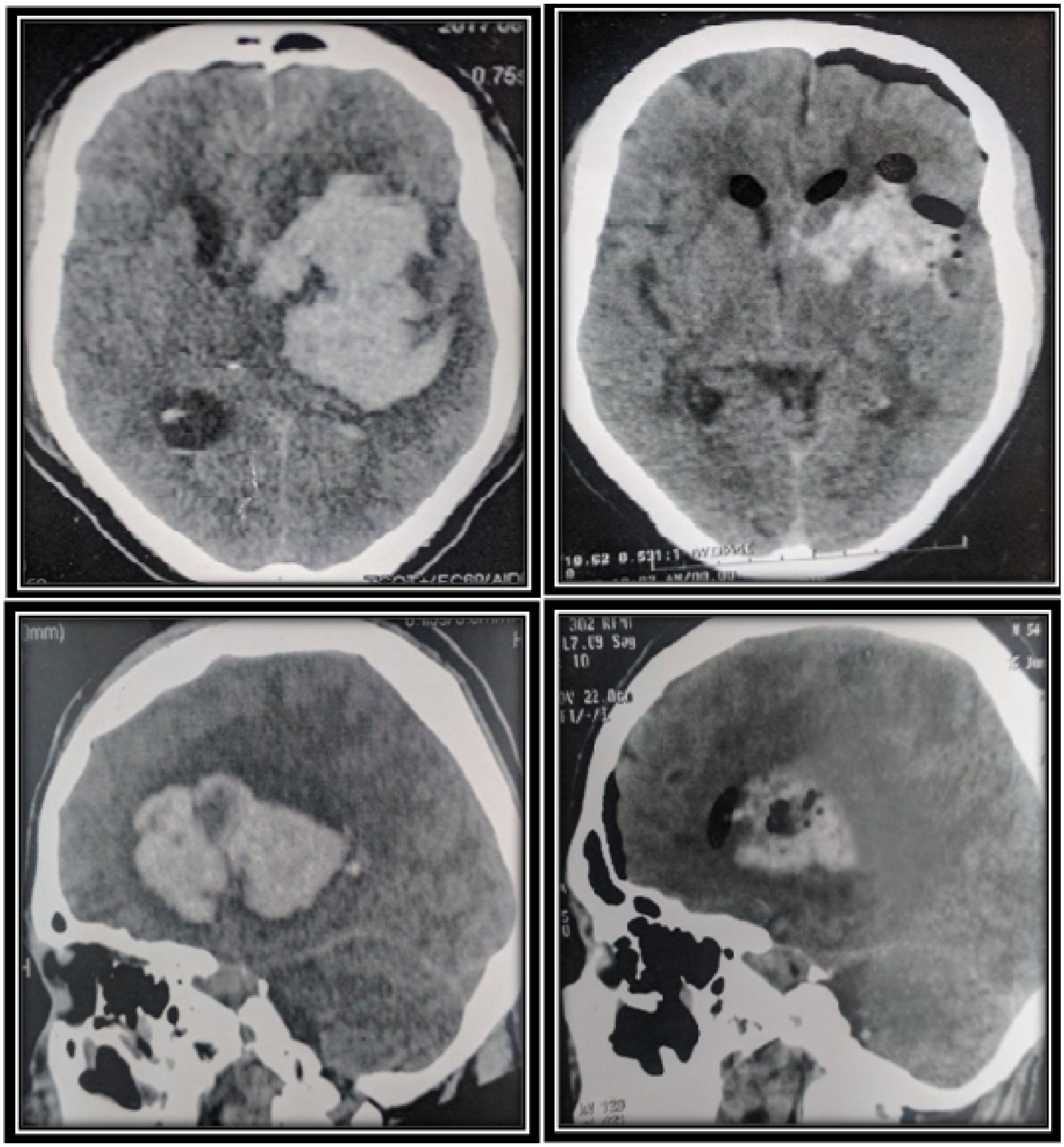

Fig. (7) showing comparison between preoperative CT brain (axial, sagital) of a male 55y. patient has left 55cc hematoma with GCS 7 and postoperative CT brain (axial, sagital) of the same patient with surgical entery point at kocher's point. Evacuation rate was 83.6 %.

Table (2): Comparison between pre- and post- operative (7th day) according to Glascow Coma Scale (GCS) (n= 20)

GCS	**Pre**	**Post**	**t**	**p**
Min. – Max.	**7.0 – 11.0**	**3.0 – 15.0**	**4.182***	**0.001***
Mean ± SD.	**8.35 ± 1.35**	**11.0 ± 3.60**		
Median	**8.0**	**11.0**		

t: Paired t-test

p: p value for comparing between pre and post

*: Statistically significant at $p \leq 0.05$

Table (3): Relation between Entry point with different parameters (n= 20)

	Entry point		**Test of sig.**	**p**
	Kocher (n= 9)	**Frontal (n= 11)**		
Glascow Outcome Score				
Min. – Max.	1.0 – 3.0	2.0 – 4.0	U=5.50*	<0.001*
Mean ± SD.	2.0 ± 0.71	3.73 ± 0.65		
Median	2.0	4.0		
Postoperative 7th day GCS				
Min. – Max.	3.0 – 11.0	9.0 – 15.0	t=4.739*	<0.001*
Mean ± SD.	8.11 ± 3.02	13.36 ± 1.91		
Median	9.0	14.0		
Evacuation rate				
Min. – Max.	64.0 – 90.0	82.20 – 98.30	t=5.815*	<0.001*
Mean ± SD.	73.87 ± 9.32	93.90 ± 4.95		
Median	70.0	95.70		

U: **Mann Whitney test**: **Student t-test**

p: p value for association between Entry point with different parameters

*: Statistically significant at $p \le 0.05$

Table (4): Distribution of the studied cases according to different parameters

	No.	**%**
Mortality	2	10
Rebleeding	1	5
Ventricular drain	4	20
Favorable Outcome GOS	9	45
Unfavorable Outcome GOS	11	55

4. Discussions

Brain injury after ICH is related to mechanical compression and the toxic effect of the blood clot.(11, 13) The principal aim of surgical intervention is reducing hematoma volume, preventing further hemorrhage, relieving mass effect, and reducing intracranial pressure rapidly, thereby preventing secondary neurologic deterioration by relieving local ischemia or removal of noxious chemicals.(14-16) But the decision about whether and when to undertake surgical evacuation of ICH remains controversial.(11)

For patients who have lobar ICH >30 mL and within 1 cm of the surface, removal of supratentorial ICH by standard craniotomy might be considered.(17) Historically, craniotomy has been speculated as an appropriate treatment for ICH evacuation.(18) However, its benefits are marginal at best, and the applications remain controversial. A number of surgical trials have confirmed that craniotomy tends to be more harmful than beneficial, which was attributed to great tissue damage without improved clinical outcomes.(19,20) Therefore, a minimally invasive surgery treatment related to clot evacuation has been under intensive focus in treating ICH over craniotomy. (21)

However, the effectiveness of minimally invasive ICH evacuation using an endoscopic approach is uncertain and is considered investigational.(17) Accumulating evidence indicates that patients with ICH who underwent minimally invasive surgery had less tissue damage and blood loss, lighter cerebral swelling and edema, shorter operative time and hospital stay, rapid postoperative recovery, as well as greater functional outcomes as compared to the conservative craniotomy.(22-24)

Endoscopic evacuation of intracerebral hemorrhage was first reported by Auer in 1985.(25-27)The endoscopic hematoma evacuation technique has been under development for nearly 2 decades. Several important technical developments were reported by various groups to enhance its orientation, visualization, and safety(23)

One important improvement is the transparent sheath, which is used as a working channel for the endoscopic and surgical instruments.(28, 29) Following the first detailed description by Nihishara et, al.(29) this technique was widely adopted by many surgeons for endoscopic hematoma evacuation surgery.(12, 23, 30-34) Using this apparatus, instruments can be inserted through the working channel to remove clots and coagulate bleeding vessels without injuring the surrounding brain tissue.(35)

The present study aimed at studying the surgical outcome of endoscopic evacuation of spontaneous supratentorial intracerebral hematoma in which twenty patients were encrypted with their data in this study.

In our study, the mean preoperative hematoma volume was 43.5 ml ranging from 30 to 65 ml and the mean postoperative hematoma volume was 7.55 ml ranging from 0.5 to 22 ml with a statistically significant P value between them ($P<0.001$). The mean evacuation rate was 84.89 % ranging from 64 to 98.3 %.

Our slightly low ecavuation rate may be explained by in our experience, some hematoma clots were closely adhered to arteries or located far away from the center of the hematoma. Removing these clots might require more intensive coagulation attempts or more swinging of the sheath, resulting in damage to brain tissue. For this reason, we advanced the hypothesis that aggressive and radical hematoma removal might not be necessary during endoscopic hematoma evacuation procedures. However, our evacuation rate was within accepted range reported by other groups using similar techniques (i.e., transparent sheath and endoscope) which was from 80% to 99**%**.(28, 29, 34, 36)

These data were compatible with the data reported by **Lichao Ma et, al. 2017** where the mean preoperative hematoma volume was 45.48 ml ranging from 29.19 to 79.30 ml and the mean postoperative hematoma volume was 5.51 ml ranging from 0.48 to 19.49 ml. The mean evacuation rate was 87%.(35) Also with **Feng Y. et al 2016** in a study of 93 patients underwent endoscopic evacuation of ICH, in which the mean evacuation rate was 83.52%.(37)

Other studies reported higher values as **Eroglu U et, al. 2018** where the mean preoperative hematoma volume was 53.07 ml with mean evacuation rate was 93.7 %,(38) also **W.-H. Wang et al. 2015** reported a mean preoperative hematoma volume was 61.2 ml ranging from 30 to 140 ml with median evacuation rate 90% ranging from 60 to 99%.(12)

11 patients (55%) in our study surgically operated by a Frontal entery point while 9 patients (45%) surgically operated by a Kocher entery point and when comparing each entery point in correlation with evacuation rate and GOS, revealed that the Frontal entery point had a better results with both evacuation rate (mean 93.9%, ranging 82.2 to 98.3%) and GOS (median 4) in comparison with the results of the Kocher entery point which was 73.87% mean evacuation rate, (ranging from 64 to 90%) and median GOS 2. These data were statistically significant value ($P<0.001$), denoting the preference of the Fronalentery point.

Agreed with that, **Lichao Ma et, al. 2017** who believed that the Frontal approach is safe and convenient for most basal ganglia hematomas. for the following reasons. 1) The trajectory pans across noneloquent brain tissue of the frontal lobe without any important vessels. 2) The trajectory is close to the long axis of the hematoma. 3) It is relatively simple to keep the trajectory correct during surgery because the patient's head is positioned supine.(35)

Also, **Hung-Lin Lina et, al. 2010** reported a slight better rate of evacuation in the group of Frontal approaches compared with temporal approaches (83% vs. 81%). Although the frontal approaches represented a longer working distance from the trephination to the hematoma center, the larger contact area between the endoscopic view and hematoma was gained through a limited trephination and a minimal range of motion of the endoscope limiting brain tissue trauma during the surgery.(39)

On the contrary**, W.-H. Wang et al 2015** used the Kocher entery point in most of their cases with accepted evacuation rate (ranging from 60 to 99%) and GOS (median 3).(12)

The mean preoperative GCS of patients in our study was 8.35, ranged from 7 to 11 while the mean postoperative (7th day) GCS was 11 ranged from 3 to 15. There was statistically significant improvement in GCS at 7th day postoperative when compared to preoperative GCS ($P=0.001$).

These data correlated with data reported by **Lichao Ma et, al. 2017** where the average GCS scores recovered from 8 to 13 during the first 7 days after surgery, with a significant difference ($P = 0$).(35) Also with **L. Kuo et al. 2011** who reported the mean preoperative GCS score was 7.1 and the mean GCS score 1 week after surgery statistically significant improved to 11.(34)

In comparison with craniotomy, **Eroglu U et, al. 2018** reported GCS increased from 6 to 11 at 1 week postoperatively in endoscopic group vs increasing from 5 to 9 in craniotomy group.(38) Also **Toru Nagasaka et, al. 2011** reported that the mean GCS score at day 7 was 12 for the endoscopy group and 9.1 for the craniotomy group ($P <0.05$).

The mean change in GCS score was +4.8 for the endoscopy group and -0.1 for the craniotomy group ($P <0.001$). The improved GCS score in the endoscopy group indicated that early evacuation of hematoma with a minimally invasive method promotes early recovery in patients with ICH. Early improvements in consciousness can be attributed to early decompression and less invasive endoscopic surgery.(33)

In our study, the median GOS was 3 ranging from 1 to 4 with 9 patients (45%) had a favorable outcome and 11 patients (55%) had unfavorable outcome. These data is higher than data reported by **Zhu et al. 2012** where 25% good outcomes in 28 patients 3 months after surgery(40) and lower than data reported by **Nishihara et al 2007** where 55% good outcome in 27 patients at 6 months.(28)

W.-H. Wang et al. 2015 reported the median GOS evaluated 6 months and 1 year postoperatively was 3, but when comparing with results in craniotomy group, good short-term surgical outcome for endoscopic surgery, but no benefit for long-term functional recovery.(12)

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