CLINICAL AND RADIOLOGICAL STUDY OF PATIENTS WITH SKULL BASE FRACTURE AFTER HEAD INJURY

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ABSTRACT

Traumatic brain injury (TBI) is the largest contributor to morbidity and mortality in various parts of the world. Skull base fracture (SBF) is one of the many manifestations that can occur in cases of mild to severe TBI. With varying patterns of TBI, it was necessary to review the characteristics of SBF, clinical manifestations, cerebrospinal fluid leakage, and complications. The data were taken from the medical records of SBF patients who were treated at RSUD (Regional Public Hospital) Dr. Soetomo in the period January 2014 - July 2019. Then, the data obtained were written on the collection sheet and analyzed descriptively using RKward. It was found that SBF most often occurs due to severe TBI (60.14%). 77.7% of SBF patients were male and 35.1% of all patients aged 15-24 years. The most frequent cause was traffic accidents (86.5%). The anterior cranial fossa (ACF) was the most frequently fractured part of the skull base (30.4%). There was a significant relationship between the severity of TBI with the occurrence of CSF leakage and complications. About 33 patients (22.3%) had complications such as pneumocephalus and 9 patients (6.1%) had meningitis. Complications in the form of brain abscess and hydrocephalus in 1 (0.7%) patient each. SBF often occurred in men of productive age 15-24 years. The ACF was the most frequently fractured part. The majority were caused by traffic accidents accompanied by severe brain injuries. The most common complications were pneumocephalus, meningitis, brain abscess, and hydrocephalus.

***Keywords**: Head injury; skull base fracture; clinical sign; complications; human & health*

ABSTRAK

Traumatic brain injury (TBI) merupakan penyumbang terbesar angka morbiditas dan mortalitas di berbagai belahan dunia. Skull base fracture (SBF) merupakan salah satu dari sekian banyak manifestasi yang dapat terjadi pada kasus TBI ringan - berat. Dengan bervariasinya pola TBI, maka dibutuhkan peninjauan kembali mengenai karakteristik SBF, manifestasi klinis, kebocoran cairan serebrospinal, dan komplikasi. Data diambil dari rekam medis pasien SBF yang dirawat di RSUD (Rumah Sakit Umum Daerah) Dr. Soetomo pada periode Januari 2014 - Juli 2019. Kemudian data yang diperoleh ditulis pada lembar pengumpulan dan dianalisis secara deskriptif menggunakan RKward. Didapatkan data bahwa SBF paling sering terjadi akibat TBI berat (60.14%). Sebanyak 77.7% pasien SBF berjenis kelamin laki-laki dan 35.1% dari keseluruhan penderita berusia 15-24 tahun. Penyebab paling sering ialah kecelakaan lalu lintas (86.5%). Anterior cranial fossa (ACF) merupakan bagian dasar tengkorak yang paling sering mengalami fraktur (30.4%). Terdapat hubungan yang signifikan antara derajat keparahan TBI dengan terjadinya kebocoran CSF dan komplikasi. Sekitar 33 pasien (22.3%) mengalami komplikasi berupa pneumocephalus dan 9 pasien (6.1%) mengalami meningitis. Komplikasi berupa brain abscess dan hydrocephalus masing-masing sebanyak 1 pasien (0.7%). SBF sering terjadi pada laki-laki dengan usia produktif 15-24 tahun. ACF merupakan bagian yang tersering mengalami fraktur. Mayoritas disebabkan oleh kecelakaan lalu lintas yang disertai cedera otak berat. Komplikasi paling banyak dijumpai adalah pneumocephalus, meningitis, abses otak, dan hydrocephalus.

***Kata kunci**: Cedera kepala; fraktur dasar tengkorak; tanda-tanda klinis; komplikasi; human & health*

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INTRODUCTION

Traumatic Brain Injury (TBI) is defined as a change in brain function or pathology in the brain caused by external influences (Menon et al 2010). TBI is the most common cause of morbidity and mortality in many countries (Popescu et al 2015, Khellaf et al 2019). The incidence of TBI in each country has its variations and it is estimated that every year there are 69 million people in all parts of the world who experience TBI with the highest incidence in countries of Southeast Asia and the West Pacific (Dewan et al 2018). In Indonesia, injuries to the head rank third after the lower and upper limbs, which are in first and second place (Ministry of Health 2019).

Skull base fracture (SBF) is one of the manifestations of TBI which is mostly caused by blunt force trauma. Sometimes, SBF goes undiagnosed because of less than optimal computed tomography (CT) operation. In contrast to other TBI manifestations such as subdural hematoma, extradural hematoma, and facial trauma which are very distinct clinically and radiologically (Sivanandapanicker et al 2018, Olabinri et al 2015, Bondada & Rao 2020). SBF can occur in the anterior cranial fossa (ACF), middle cranial fossa (MCF), and posterior cranial fossa (PCF) in the form of single or multiple fractures. At the base of the skull there are many important structures including blood vessels and nerves so that in the case of SBF, various complications are often encountered depending on the part and structure that is damaged (Sokoya et al 2017, Baugnon & Hudgins 2014). Due to the various causes and patterns of TBI in each country and there is still little data in Indonesia, it is necessary to review the causes, characteristics, clinical manifestations, CSF leakage, and complications in SBF patients.

MATERIALS AND METHODS

Data retrieval using medical records of patients who experienced SBF in January 2014 to July 2019 who were treated at Dr. Soetomo Hospital, Surabaya, East Java, Indonesia. The definitive diagnosis of SBF patients was based on the results of radiological examinations using computed tomography (CT). The data taken include gender, age, mechanism of trauma, location, clinical manifestations, and complications. The sex ratio was the ratio of the number of male to female patients. The mechanism of injury was divided into three groups which were road traffic accident (RTA), fall from height, and being hit by an object. The difference between RTA and hit by an object was that RTA was all forms of accidents involving motorized vehicles and occurring on the highway either as a driver or a passenger. The age grouping was based on the division of the working-age population by the Central Statistics Agency.

TBI severity stratification was based on GCS score conversion: mild (13-15), moderate (9-12), severe (≤8). This study obtained ethical approval from Dr. Soetomo Ethical Committee with number 1299/KEPK/VII/2019. This research conducted a descriptive statistical analysis using RKward software version 0.7.1. The results of the analysis were considered statistically significant when $p<0.05$.

RESULTS

Table 1. General characteristics of patients with SBF

Characteristics	Number of patients	Percentage (%)
Sex		
Male	115	77.7
Female	33	22.3
Mechanism of injury		
RTA	128	86.5
Fall from height	12	8.1
Hit by object	8	5.4
Age range (years)		
5-14	3	2.0
15-24	52	35.1
25-34	21	14.2
35-44	25	16.9
45-54	27	18.2
55-64	18	12.2
>64	2	1.4
Locations		
ACF	45	30.4
MCF	42	28.4
PCF	4	2.7
ACF + MCF	44	29.7
ACF + MCF + PCF	6	4.1
MCF + PCF	7	4.7
Clinical manifestations		
Periorbital ecchymosis	88	59.5
Postauricular ecchymosis	6	4.1
CSF leak	102	68.9
Rhinorrhea	27	26.5
Otorrhea	28	27.5
Rhinorrhea + otorrhea	47	46.1
No CSF leak	46	31.1
GCS		
≤8	89	60.1
9-12	35	23.6
13-15	24	16.2
Complications		
Pneumocephalus	33	22.3
Meningitis	9	6.1
Brain abscess	1	0.7
Hydrocephalus	1	0.7

RTA: road traffic accident; ACF: anterior cranial fossa; MCF: middle cranial fossa; PCF: posterior cranial fossa; GCS: glasgow coma scale; CSF: cerebrospinal fluid

Overall, this study obtained data on 148 patients who experienced SBF with the majority of patients was male 115 (77.7%). Obtained data on the sex ratio between men and women was 3.5. In this study, it can be seen that the mechanism of trauma that most often causes SBF was RTA (86.5%). Moreover, it was also found that SBF was mostly caused by severe head trauma (60.1%) and the majority of patients had an age range of 15-24 years (35.1%). Based on the results of head CT radiology, the majority of fractures occurred in the ACF (30.4%). Then based on the clinical manifestations experienced by the patient, it was found that 88 patients (59.5%) had periorbital ecchymosis and 6 patients (4.1%) had retroauricular ecchymosis. A total of 102 patients (68.9%) had CSF leakage with 47 (46.1%) of them having rhinorrhea + otorrhea. 33 patients (22.3%) had pneumocephalus and 9 patients (6.1%) had meningitis. Then, patients with brain abscess and hydrocephalus were 1 (0.7%) patient each.

Table 2. Characteristics of SBF patients based on age

Age range (years)	5-14	15-24	25-34	35-44	45-54	55-64	>64	Total
Total	3	52	21	25	27	18	2	148
Male/Female (sex ratio)	2/1 (2.0)	47/5 (9.4)	17/4 (4.3)	17/8 (2.1)	17/10 (1.7)	14/4 (3.5)	1/1 (1.0)	115/33 (3.5)
Mechanism of injury (%)								
RTA	2 (66.7)	50 (96.2)	15 (71.4)	23 (92.0)	24 (88.9)	13 (72.2)	1 (50.0)	128 (86.5)
Fall from height	0	1 (1.9)	4 (19.0)	2 (8.0)	3 (11.1)	2 (11.1)	0	12 (8.1)
Hit by object	1 (33.3)	1 (1.9)	2 (9.5)	0	0	3 (16.7)	1 (50.0)	8 (5.4)

RTA: road traffic accident

Table 2 shows that the sex ratio of SBF patients was highest in patients with an age group of 15-24 years (9.4), followed by an age group of 25-34 years (4.3) while the lowest sex ratio was in the age group >64 years (1.0). Based on the mechanism of injury, in RTA the majority of patients were aged 15-24 years (50/128, 39.1%), and in the case of falling from a height dominated by the age of 25-34 years (4/12, 33.3%) while in the case of hit by object dominated by 55-64 years old (3/8, 37.5%).

Table 3. Characteristics of SBF patients based on mechanism of injury

Mechanism of injury	RTA	Fall from height	Hit by object	Total	p
Total	128	12	8	148	
Male/Female (sex ratio)	98/30 (3.3)	12/0	5/3 (1.7)	115/33 (3.5)	1.000[a]
Location (%)					
ACF	37 (28.9)	6 (50.0)	2 (25.0)	45 (30.4)	
MCF	34 (26.6)	3 (25.0)	5 (62.5)	42 (28.4)	
PCF	4 (3.1)	0	0	4 (2.7)	
ACF + MCF	40 (31.3)	3 (25.0)	1 (12.5)	44 (29.7)	
ACF + MCF + PCF	6 (4.7)	0	0	6 (4.1)	
MCF + PCF	7 (5.5)	0	0	7 (4.7)	
GCS (%)					1.000[a]
≤8	77 (60.2)	9 (75.0)	3 (37.5)	128 (86.5)	
9-12	29 (23.6)	3 (25.0)	3 (37.5)	12 (8.1)	
13-15	22 (16.2)	0	2 (25.0)	8 (5.4)	

[a] Kolmogorov-Smirnov test; RTA: road traffic accident; ACF: anterior cranial fossa; MCF: middle cranial fossa; PCF: posterior cranial fossa; GCS: glasgow coma scale

Based on table 3, in cases of falling from a height, the fracture location most often occurred in ACF with a prevalence of 50.0%, then in the hit by object case, the location that often experienced fractures was MCF at 62.5%, while in the case of RTA, the most frequently fractured location was ACF + MCF with a prevalence of 31.3%.

Table 4. Characteristics of SBF patients based on GCS score

GCS	≤8	9-12	13-15	Total	p
Total	89	35	24	148	
Male/Female (sex ratio)	72 /17 (4.2)	25/10 (2.5)	18/6 (3.0)	115/33 (3.5)	0.491[a]
Type of skull base fracture (%)					0.248[a]
Single fracture	50 (56.2)	25 (71.4)	16 (66.7)	91 (61.5)	
Multiple fracture	39 (43.8)	10 (13.5)	8 (33.3)	57 (38.5)	
CSF leak (%)	62 (69.7)	30 (85.7)	10 (41.7)	102 (68.9)	0.002[a]
Rhinorrhea	11 (12.4)	11 (31.4)	5 (20.8)	27 (26.5)	
Otorrhea	16 (18.0)	10 (28.6)	2 (8.3)	28 (27.5)	
Rhinorrhea + otorrhea	35 (39.3)	9 (25.8)	3 (12.5)	47 (46.1)	
No CSF leak	27 (30.3)	5 (14.3)	14 (58.3)	46 (31.1)	
Complication (%)					0.004[a]
Pneumocephalus	12 (13.5)	9 (25.7)	12 (50.0)	33 (22.3)	
Meningitis	6 (6.7)	1 (2.9)	2 (8.3)	9 (6.1)	
Brain abscess	1 (1.1)	0	0	1 (0.7)	
Hydrocephalus	0	1 (2.9)	0	1 (0.7)	

[a] Chi-Square test; GCS: glasgow coma scale; CSF: cerebrospinal fluid

In table 4, the majority of SBF patients had single fractures (61.5%). Then based on the results of statistical analysis, there was a correlation between CSF leakage and complications with GCS (p-value <0.05). Moreover, patients with a GCS score of ≤8 experienced the most clinical manifestations in the form of rhinorrhea + otorrhea (39.3%). On the other hand, patients with a GCS score of 9-12 experienced the most rhinorrhea (31.4%), whereas, in the GCS score of 13-15, CSF leakage was often not found (58.3%).

Table 5. Characteristics of clinical manifestations based on site of SBF

Location	ACF	MCF	PCF	ACF+MCF	ACF+MCF+PCF	MCF+PCF	Total
Total	45	42	4	44	6	7	148
Periorbital ecchymosis (%)	31 (28.9) p = 0.123[a]	14 (33.3) p <0.001[a]	2 (50.0) p = 1.000[b]	33 (75.0) p = 0.012[a]	5 (83.3) p = 0.402[b]	3 (42.9) p = 0.442[b]	88 (59.5)
Postauricular ecchymosis (%)	1 (2.2) p = 0.668[b]	2 (4.8) p = 1.000[b]	0	2 (4.5) p = 1.000[b]	0	1 (14.3) p = 0.256[b]	6 (4.1)
CSF leak (%)	30 (66.7)	33 (78.6)	3 (2.8)	27 (61.4)	5 (83.3)	4 (57.1)	102 (68.9)
Rhinorrhea	14 (31.1) p = 0.007[a]	5 (11.9) p = 0.209[a]	0	7 (15.9) p = 0.632[a]	1 (16.7) p = 1.000[b]	0	27 (26.5)
Otorrhea	5 (11.1) p = 0.109[a]	14 (33.3) p = 0.005[a]	2 (50.0) p = 0.162[b]	4 (9.1) p = 0.047[a]	1 (16.7) p = 1.000[b]	2 (28.6) p = 0.617[b]	28 (27.5)
Rhinorrhea + otorrhea	11 (24.4) p = 0.207[a]	14 (33.3) p = 0.795[a]	1 (25.0) p = 1.000[b]	16 (36.4) p = 0.434[a]	3 (50.0) p = 0.382[b]	2 (28.6) p = 1.000[b]	47 (46.1)
No CSF leak (%)	15 (33.3) p = 0.696[a]	9 (21.4) p = 0.110[a]	1 (25.0) p = 1.000[b]	17 (38.7) p = 0.196[a]	1 (16.7) p = 0.666[b]	3 (42.9) p = 0.677[b]	46 (31.1)

[a] Chi-Square test; [b] Fisher's exact test; ACF: anterior cranial fossa; MCF: middle cranial fossa; PCF: posterior cranial fossa; CSF: cerebrospinal fluid

In table 5, based on statistical analysis, it was found that there was a significant correlation between fractures in the ACF + MCF with the presence of clinical manifestations in the patient in the form of periorbital ecchymosis (p-value <0.05). In MCF fractures, the same results were also obtained, namely correlating with clinical manifestations in the form of periorbital ecchymosis. It was also found that there was a correlation between fractures in ACF and clinical manifestations of rhinorrhea (p-value <0.05). Moreover, the MCF fracture correlated with the incidence of otorrhea (p-value <0.05), and the ACF + MCF also showed the same results, which was correlated with the clinical manifestations of otorrhea. Meanwhile, for fractures occurring at other locations,

there was no correlation with the CSF leak (p-value >0.05).

DISCUSSION

Skull base fracture (SBF) is a linear fracture of the skull base. The base of the skull consists of the frontal, ethmoid, sphenoid, temporal, parietal, and occipital bones. Fractures that occur at the base of the skull can tear the membranes that line the brain, causing CSF leakage. This CSF leak can come out through the nose (CSF rhinorrhea) or ears (CSF otorrhea), with or without other manifestations such as periorbital ecchymosis (Raccoon eyes) or postauricular ecchymosis (Battle sign). These clinical signs are pathognomonic in patients with skull base fractures (Wani et al 2013, Baugnon & Hudgins 2014, Faried et al 2019).

Anatomically, the skull base is divided into three parts which are the anterior, middle, and posterior fossa. In a recent study, it was stated that the ACF is the part of the base of the skull that fractures the most (Wani et al 2013, Sivanandapanicker et al 2018). However, other literature states that the MCF is the most frequently fractured site (Olabinri et al 2015, Yellinek et al 2015). In our study, the most commonly fractured skull base was ACF (30.4%), followed by ACF + MCF (29.7%), and MCF (28.4%). The high prevalence of fractures in ACF and MCF is because, in traffic accidents, the victim will tend to fall forward. On the other hand, the MCF is the base of the skull which is composed of the thinnest bone with many foramina compared to the anterior and posterior fossa. However, in PCF, less fracture occurs because anatomically this part is composed of the thick occipital bone (Olabinri et al 2015).

In previous studies, SBF most often occurs in patients with traffic accidents and severe head trauma with a prevalence ranging from 3.5%-45.4% (Wani et al 2013, Olabinri et al 2015, Yellinek et al 2015, Sivanandapanicker et al 2018, Wang et al 2018). In our study, similar results were obtained that the majority were caused by severe head trauma (60.1%) and traffic accidents (86.5%). This high prevalence is inseparable from the fact that every year traffic violations in Indonesia tend to increase so that it has an impact on increasing the number of traffic accidents.

The reason why the prevalence of SBF was high in men (77.7%) was that men tend to take more risks and do more outdoor activities. Then this study also obtained data that the majority of SBF patients had an age range of 15-24 years (35.1%). Moreover, the age range of 15-24 years also dominated SBF cases due to an RTA of 39.1% (n = 50/128). This is due to the lack of ability and experience in driving a motorcycle, tendency to take risks, and the low ability to control emotions. This high prevalence is also supported by the fact that in Indonesia, the working-age population is dominated by men. Then the age range of 15-24 years was most experienced injuries due to traffic accidents (Ramadiputra et al 2018). As well as previous research also states that increasing age will be followed by emotional stability (Carstensen et al 2011).

Figure 1. Fracture on ACF (left), MCF (middle), PCF (right)

This study found that SBF patients had meningitis occurring in 9 patients (6.1%), of which 77.8% (n = 7/9) were in patients with CSF leak. Moreover, complications such as pneumocephalus were also found in 33 patients (22.3%). In previous studies, the incidence of pneumocephalus was only about 1% in TBI cases, but this prevalence can increase by 8% if there is a fracture of the skull base and increase by 41% if the fracture involves the sella turcica (Pillai et al 2017, Al-Aieb et al 2017, Eom 2020). The gold standard in establishing a definitive diagnosis of SBF is to use a CT scan (Manarisip et al 2014). However,

clinical symptoms also play an important role in establishing the diagnosis (Feldman et al 2017, Orrù et al 2018). In this study, 88 patients (59.5%) had a clinical manifestation of periorbital ecchymosis, and 6 patients (4.1%) had postauricular ecchymosis. Then it was found that 102 patients (68.9%) had cerebrospinal fluid leakage, of which 46.1% (n = 47/102) were CSF rhinorrhea + otorrhea. The prevalence of rhinorrhea + otorrhea was high because in this study the majority of fractures were in the ACF and MCF.

Interestingly, our data showed that patients with a GCS score of ≤8 had more single fractures than multiple fractures, but there was no statistically significant correlation (p-value >0.05). We suspect that this may be due to other factors such as the presence of intracranial hemorrhage. Based on statistical analysis, we found that fracture in ACF was correlated with the presence of clinical manifestations of rhinorrhea (p-value <0.05). Then the fractures that occurred in the ACF + MCF and MCF correlated with clinical manifestations in the form of otorrhea (p-value <0.05). Moreover, we found that fractures in the MCF and ACF + MCF correlated with the appearance of periorbital ecchymosis (p-value <0.05). These results contradict previous studies, that the onset of clinical manifestations in the form of periorbital ecchymosis is correlated with fractures in the ACF, while postauricular ecchymosis is correlated with fractures that occur in the MCF (Mei et al 2020). The limitations of our study are mainly regarding the sample size and most of the mechanisms of injury are traffic accidents. However, we believe that this study can help to estimate the fracture site if CT cannot be performed and create rapid awareness in patients with SBF. Further research is needed to look at more in-depth characteristics and long-term results.

CONCLUSION

Skull base fracture (SBF) is one of the manifestations that can occur as a result of head injury. Proper diagnosis and treatment are very important because they can affect the patient's prognosis. This study shows that there are variations in the causes, characteristics, clinical features, radiological features, and complications that occur in head injuries with skull base fractures.

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