Surgical Outcome of Traumatic Aortic Disruption of the Thoracic Aorta in Songklanagarind Hospital

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This retrospective study collected data from 11 patients who underwent TDTA' repair from February 1987 to June 2003, 10 patients were men (90.9%) and 1 was a woman (9.09%) with a mean age of 32 years. All patients had a blunt injury from a violent motor vehicle accident. None of them required thoracotomy at the emergency room. Standard chest x-ray was done in every patient and the widening of the upper mediastinum was mainly found in 10 patients (90.9%), hemothorax in 8 patients, blurred aortic knob in 7 patients, lower left main bronchus in 3 patients, pleural apical cap in 2 patients and pneumothorax in 1 patient, 8 patients were investigated by CT scan and presented a positive study. 3 patients (27.27%) were diagnosed by both aortogram and CT scan and a pseudo-false aneurysm was found. Multi organ system injury was mainly found in 10 patients (90.91%). 7 patients (63.64%) had hypovolumic shock on admission,3 patients died postoperation and 2 of them had experience of postoperative paraplegia. Clamp and sew technique was used in 6 patients (54.54%). The duration of aortic cross clamp time ranged from 19-67 minutes (mean time = 39.30 min.) Pneumonia was the significant postoperative complication found in 3 patients, including acute renal failure, ARDS (all died) and paraplegia in 2 patients. The duration of the aortic cross clamp time that was used in the patients who presented with paraplegia was more than 40 minutes. 1 patient had delayed the aortic repair for 3 weeks resulting from severe brain contusion. 5 patients (45.45%) died in hospital. 1 patient died in the operating theatre, 4 of them (36.36%) died during postoperatively within 24 hours. The mainly cause of death which occurred in every patient was intraoperative cardiac arrest, the others were postoperative bleeding, ARDS and arrhythmias. The mean of length of stay in the intensive care unit was 6.94 days. The period of hospitalization ranged from 11 to 180 days (mean = 62.83 days).

The small sample size is the limitation for the present study. The authors plan to do prospective study about the factors which influence the mortality rate and factors related to postoperative paraplegia in TDTA patients at Songklanakarind Hospital.

Keywords : *TDTA patient, Surgical outcome*

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Traumatic Disruption of the Thoracic Aorta (TDTA) is the second cause of death after head injury in motor vehicle accident patients[1]. It was found from the autopsy that 15-23% of the patients who died had the condition of TDTA[2].

Eighty percent of patients with TDTA died at the accident area from free rupture and exanguination into the chest[3]. It was estimated that half of the survivors died within 24 hours, and almost 75% died within a week after the accident, especially if there was no definitive treatment[4]. Moreover, Kodali and co-workers found that 57% of TDTA patients died before surgery[5]. Recent meta analysis studies found that 18-20% of the mortality rate after surgical intervention was associated with the TDTA[6,7].

Increasing the survival rate of TDTA patients depended on the aggressive diagnosis and the duration of operation. The mortality rate of TDTA was correlated with preoperative factors of the patients such as age, types and severity of associated injuries[8], duration of diagnosis and operative repair[5,9]. TDTA'

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patients with multiple injury were the criteria for purposeful surgery delay to treat other life-threatening states, but the incidence of the mortality or morbidity rate was the same as the immediate operation' group[10].

Spinal cord ischemia and paraplegia are the most dreadful postoperative complications from TDTA repair, resulting from thoracic aortic cross-clamping. Despite the vast literature, spinal cord protection remains to be controversial to conclude the optimal method. Many groups have suggested using bypass surgery for the lower extremity and spinal cord perfusion during aortic cross-clamping[7]. On the other hand, many surgeons have had acceptable results by using the "clamp and sew" technique[11,12].

The purpose of the present retrospective study in TDTA patients was to identify preoperative variable data, to identify surgical techniques and associated postoperative complications, to report the surgical outcomes and factors that affected surgical outcomes, to identify mortality and morbidity rate from surgery, and finally to identify the incidence of paraplegia and to examine factors related to paraplegia and the impact of surgical techniques on the incidence of paraplegia.

Material and Method

Patients who were diagnosed with thoracic aortic injury were identified through the Trauma Registry at Songklanagarind Hospital, Faculty of Medicine, Prince of Songkla University, Hatyai, Thailand. Patients' medical record forms were developed by literature review for collecting demographic data, mechanism of injury, associated injuries, initial hypotension on arrival, radiographic studies, duration from injury to diagnosis, duration from diagnosis to surgical correction, operative findings, technique of operative repair, aortic clamp time, adjunctive distal perfusion techniques, presence of postoperative paraplegia and presence of post operative complications and death. Renal failure in this study was defined as a creatinine persistently greater than 2 mg/dl or needing hemodialysis. Adult Respiratory Distress Syndrome (ARDS) was diagnosed by chest radiographic and arterial blood gas.

The data were collected from 11 patients who underwent TDTA' repair from February 1987 to June 2003. 10 patients were men (90.9%) and 1 was a woman (9.09%). The average age ranged from 19 to 56 years (mean age, 32 years). All patients had been victims of violent motor vehicle accidents involving a mechanism of sudden deceleration. None of them required thoracotomy at the emergency room.

Seven patients (63.64%) had hypovolumic shock or preoperative hypotension (defined as systolic blood pressure less than 90 mmHg) on admission, resulting from isolated aortic an injury in 1 patient, from associated injuries in 4 patients, from aortic injury concomitant with associated injury in 2 patients and both of them had pelvic fracture.

Four patients (36.36%) presented with rib fractures, one patient (9.09%) had flail chest.Two patients (18.18%) experienced pseudocoarctation syndrome with diminished femoral pulses.

Seven patients (63.64%) had multi organ systems injury, 3 patients (27.27%) had injuries to other organs and 1 patient (9.09%) had only an isolated aortic injury. The lesions associated with the TDTA are presented in Table 1.

One patient (9.09%) had preoperative paraplegia due to a coexisting spinal cord lesion.

Standard chest x-ray was suggested to be the possible criteria for the TDTA. From the present study, the widening of the upper mediastinum was mainly found in 10 patients (90.9%) and other associated signs are presented in Table 2.

However, 3 patients (27.27%) were not diagnosed in the preoperative period by radiographic study, because of massive hemothorax on arrival and underwent thoracotomy immediately.

3 patients (27.27%) were diagnosed by both aortogram and computerized tomography (CT scan). 5 patients (45.45%) were only investigated by CT scan, because it was clearly demonstrated the aortic lesion and the unstable conditions of the patients required immediate surgery. The radiographic study from the CT scan showed the dissection type of aorta in 5 patients (45.45%), pseudo-false aneurysm in 3 patients (27.27%), and all 3 patients (27.27%) had evidenc of pseudo-false-aneurysm from the aortogram. The mean time from injury to diagnosis in the present study was 5.6 hours (range from 2 to 14 hours). In contrast, there was delayed diagnosis in 1 patient after 98 hours of admission, because it initially showed a normal chest radiograph and mediastinal widening developed later.

The mean time from diagnosis to operation was 3.15 hours (range from 1 to 9 hours), except for 1 patient with delayed operation for 3 weeks after diagnosis, because of severe associated brain contusion.

Left posterolateral thoracotomy was used for every patient who underwent TDTA' repair. During surgery, the patients were intubated with a double-lumen tube in order to separate the ventilation of each lung**.** Operative findings are summarized in Table 3.

Table 1. Lesion associated with the aortic injury

Lesion	Patients	N	%
Thoracic lesion	4		
- Rib fracture		4	36.36
- Flail chest		1	9.09
Brain Lesion	4		
- Brain contusion		3	27.27
- Skull fracture		1	9.09
Orthopedic injury	6		
- Lower limb fracture		1	9.09
- Upper limb fracture		1	9.09
- Pelvic fracture		4	36.36
Abdominal lesions	6		
- Ruptured spleen		1	9.09
- Liver injury		4	36.36
- Stomach injury		1	9.09
- Small intestine injury		3	27.27
Peripheral vascular	1		
- Popliteal artery injury		1	9.09

Table 2. Standard chest radiographic findings

Chest radiographic findings	N	%
Widened mediastinum	10	90.9
Hemothorax	8	72.73
Blurred aortic knob	7	63.64
Tracheal deviation	3	27.27
Left bronchus lowering	3	27.27
Pleural apical cap	2	18.18
Pneumothorax	1	9.09

Table 3. Operative finding

Operative finding	N	%
Locations of aortic injury		
- Aortic isthmus	11	100.00
- Aortic arch	1	9.09
Hemothorax	8	72.73
Pulmonary contusion	7	63.64
Extend of aortic injury		
- Partial circumferential intimal tear	7	63.64
- Total circumferential intimal tear	4	36.36

Ten patients (90.9%) had aortic injury at the aortic isthmus (in the location just distal to take off of the left subclavian artery extended to the level of the ligmentum arteriosum), except one patient who had an injury at the aortic arch involving aortic isthmus.

Regarding the techniques of surgical repair, the clamp and sew technique was used in 6 patients (54.55%). The adjunctive distal perfusion techniques were used in 5 patients for spinal cord protection and lower body perfusion. Techniques of surgical repair are summarized in Table 4

The time spent for aortic cross-clamp was 39.90 minutes (average from 19 to 67 minutes). Eight patients had an aortic cross-clamp for more than 30 minutes. The operation was started from the proximal control of the aorta, and then the distal aorta was mobilized in minimization in order to avoid the interruption of intercostal artery. Prosthesis interposition graft was used for the aortic repair in all patients. Operative neurological injury was defined as a state with a sensorimotor deficit of the lower extremity that did not present at the preoperative period.

Results

Five patients (45.45%) died in the hospital. 1 patient (9.09%) died in the operating theatre. Four of them (36.36%) died during the 24 hours postoperative period. Three of the five patients who died experienced preoperative hypotension because of aortic and associated injuries. Three of them who died had undergone operation without preoperative computerized tomography (CT-Scan) and angiogram, because they had massive hemothorax and showed positive Diagnostic Peritoneal Lavage (DPL). The main cause of death which occurred in every patient was intraoperative cardiac arrest, some were caused by others as shown in Table 5.

Two patients had neurological deficits or paraplegia within the postoperative 24 hours. One was a 23 year old man with multiple injuries including liver laceration, small intestines perforation, pelvic fracture and closed head injury with brain contusion. He was repaired by using the clamp and sew technique without heparinization, his aortic cross clamp time was 58 minutes. He was noted for postoperative lower extremity paraplegia at T_3 level in the intensive care unit, however it was partially regression within 3 months. Another patient was a 23 year old man, injured in a motor vehicle

Table 4. Techniques of distal perfusion support

Techniques of distal perfusion support	N	%
Clamp and sew	6	54.55
Shunt (Ao To Ao) with Partial heparinization (1mg/kg)	3	27.27
Gott Shunt (LV apex to descending Aorta)	1	9.09
Lt. Heart bypass with centrifugal pump (LA To femoral artery)	1	9.09

Ao = aorta; LV = Left ventricle; LA = left atrial

Table 5. Circumstances, Dates, and Causes of hospital death

	Operation	Associated lesions	Dates	Causes of Death
1	Delayed	Brain contusion (severe)	Day 0 (16 hrs)	Intraoperative cardiac arrest, ARDS
2	Emergency	Stomach, Fx. Femur	Day 0 (20 hrs)	Intraoperative cardiac arrest, Bleeding, Dysrhythmias
3	Emergency	Small intestine, Fx Humerus	Day 0 (18 hrs)	Intraoperative cardiac arrest, ARDS
4	Emergency	Brain contusion (mild) Fx. pelvis	Day 0 (22 hrs)	Intraoperative cardiac arrest, Bleeding
5.	Emergency	Spleen ruptured, Liver contusion	DOT	Intraoperative cardiac arrest, Bleeding

Fx = Fracture; Day = Day Postoperative; hrs = Hours; ARDS = Adult Respiratory Distress Syndrome; DOT = Dead On Table

accident. His chest radiograph was normal on admission, but a widened mediastinum developed 4 days after admission. In this case, aortography was done to confirm the aortic isthmus tear. Aortic repair was performed with a heparin bounded shunt (Gott shunt) from the left ventricular apex to the descending aorta bypass. His aortic cross clamp time was 45 minutes. Postoperative paraplegia at T_4 level was identified when he was admitted to the intensive care unit and after two years of the follow-up period.

The neurological outcome of lower extremity and clamp times are summarized in Table 6.

The correlations of the survival outcome and death are summarized in Table 7.

Pulmonary function disturbance was the most important complication in the survival group especially pneumonia and adult respiratory distress syndrome (ARDS). Acute renal failure was another complication found in 2/6 (33.33%) patients, one patient required temporary dialysis for recovery of renal function. One of the patients in this group had an aortic cross clamp time more than 30 minutes. One patient had postoperative hoarseness, but had complete recovery 2 months later. The incidence of major morbidities are summarized in Table 8.

The length of stay in the intensive care unit ranged from 1.33 days to 18 days, median 6.94 days. The period of hospitalization ranged from 11 to 180 days, median 62.83 days.

Table 6. Correlation of Paraplegia After Repair of Traumatic Disruption of Thoracic Aorta with Clamp Time

The number of patients/Method	Clamp Time (minutes)	Paraplegia (The Number of patients)
Numbers of patients		
- 3 patients	Less than 30	0
- 4 patients	Between 30-40	0
- 4 patients	More than 40	2
Method		
- Clamp and sew (n=6)	19-58 (37.83)	1
- Shunt (n=4)	30-67 (44.25)	1
- Bypass (n=1)	35	0

Table 7. Factors Related to dead and survival

Factors	Dead	Survival
Age (years)	19-56 (35)	23-49 (29.25)
Cross-Clamp time (minutes)	25-45 (36)	19-67 (43.16)
Hemothorax (n)		
- Yes	5	3
- No	0	3
Type of Aortic tear (n)		
- Partial	3	4
- Total	2	2
Pseudo-false aneurysm Formation	3	2

Table 8. Incidence of Postoperative Complications (N=10)

Complication	N	Later results
Pneumonia	3	Recovery
Renal failure	2	Recovery after dialysis
Adult respiratory distress syndrome	2	Death
Recurrent laryngeal nerve injury	1	Complete recovery
Paraplegia	2	One of the patient was partially regression, the other was permanent paraplegia

Discussion

This study reports the clinical experience with Traumatic Disruption of the Thoracic Aorta (TDTA). The recent survey of 50 trauma centers in North America found an average of 2.2 cases of TDTA per center per year[6]. The presented retrospective study explored the critical aspects of diagnosis, operative repair, technique of distal circulatory support, surgical complications and length of hospital stay.

The hospital mortality rate was 45.45% which was higher than other studies in recent literature,[5,9,11]

which reported the range of mortality rates from 5 to 35%, according to the meta-analysis which was reported by Von Oppell et al[7]. Immediate management of aortic injuries has been greatly influenced by Parmley' s series of classic autopsy in a 257 autopsies study that 89.7% of patients who sustained a traumatic disruption of the thoracic aorta would die within 6 hours following the accident and only 9% would survive beyond 24 hours[3]. In the authors' experience, when the patients arrived at the hospital, no pre-operative death occurred.

Many studies reported that the aortic lesion was seldom found in the form of an isolated rupture of thoracic aorta[13,14]. In the present study, only one patient (9.09%) had an isolated aortic injury. Another ten patients (90.9%) had associated injuries. According to Pate et al [14], only 2 of 59 patients had an isolated rupture of the thoracic aorta. Compared to the present study, 27.27% of the patients underwent visceral operation before aortic operation because of hemodynamic instability. The coexisting lesions (for instance: ruptured spleen, liver injury, brain trauma, etc.) can cause life threatening events.

It was also found from this study that one patient had delayed aortic repair for 3 weeks after diagnosis because of severe brain contusion. Purposeful surgery delay in TDTA patients with multiple injury was aimed to have time to treat other life-threatening events. The immediate operation in this patient may lead to fatal hemorrhage of brain contusion due to the effect of full heparinization.

It becomes obvious that an immediate aortic repair is not required for every case. The hemodynamic status and neurological conditions are the significant discriminative factors for decision making[15]. Maggisano et al[16] suggested that TDTA can be managed by selective delayed operative repair. Thus, over the past decade TDTA is not only repair as emergency cases. Galli et al[17] reported that mortality rates in the acute and delayed treatment groups were 14.3% and 0%. Pierangeli[18] reported from his study that 19% of mortality rate, 14% of paraplegia and 5% of the incidence of renal failure in the emergency group versus 0% of mortality rate and complications in the delayed group.

One patient (9.09%) had normal chest radiography on admission, even when reviewed retrospectively. The duration from injury to diagnosis was 98 hours, in comparison to the median time of diagnosis being 5.6 hours**.** Mirvis et al[17] reviewed chest radiographs on admission in 205 patients with blunt trauma undergoing aortography and found that 41patients had an aortic tear. It was shown that a normal interpretation of chest radiography has a negative predictive value of 98%[18].

As described by Woodring and King[19] the majority of cases by the chest radiograph will show evidence of mediastinal abnormalities leading to aortography for diagnosis confirmation. However, a few cases use aortography to detect the minor degrees of aortic injury[15]. Recently, transesophageal echocardiography was used to detect an aortic injury with high sensitivity[20]. This investigation should be used to detect a patient with blunt chest trauma, presenting with normal or subnormal chest radiography on admission. A high level of suspicion is necessary to avoid the catastrophic results of missing aortic injury[18].

The patients in the present study had aortic thoracic injury repair by using the clamp and sew technique, heparin bounded shunt, shunt with partial hepariness and partial left heart bypass. Six cases were repaired by using clamp and sew technique and only one patient (16%) had paraplegia compared with adjunctive distal perfusion technique that had twenty percent (1 patient) of paraplegia.

In 1985, Mattox et al [11] recommended using the technique of simple aortic cross-clamping without any adjunct for intraoperative management of the traumatic injury of the descending aorta. From their study, the incidence of paraplegia was not significantly different whether cardiopulmonary bypass (CPB) was used or not (4.5 vs. 8.3%, respectively). This influenced many surgeons in believing that they could avoid using CPB and considered that the clamp and sew technique was as safe as the distal perfusion technique. The etiology of paraplegia is generally accepted that it's not only predicted by clamp time but also multi factors. However, Katz et al[21] suggested that if the duration of cross-clamping time was more than 30 minutes without distal perfusion, there would be a rapid increase in the risk of spinal cord injury. In the presented series, 2 patients with postoperative paraplegia had the duration of aortic cross-clamped time more than 40 minutes (45 and 58 minutes). Patients who underwent surgery by using the technique of distal perfusion with pump support or shunt were able to tolerate longer cross clamp times.

In the present series, the operation was delayed in 1 patient for 3 weeks after diagnosis because of severe associated brain contusion and full heparinization in surgical repair can induce fatal hemorrhage of the brain. To reduce the conflict between the necessary

use of distal perfusion and increased risk linked to heparinization, it has been recommended to use heparinless bypass systems with a centrifugal pump[7]. Heparin coated circuits could also represent an alternative method theoretically, possible from the reduction or suppression of total heparinization[22]. Gott[23] introduced the heparin bounded shunt with inflow from either the proximal aorta, or left ventricular apex and outflow to the descending aorta or femoral artery, as a means of supporting the spinal cord and viscera[21].

Regarding the aortic repair by itself, a direct end-to-end anastomosis represents an ideal operation[22]. However, graft interposition is often necessary, as it was in all the cases of the presented series. This is particularly true in cases of delayed surgery or in the presence of extend damage to aortic tissue.

The median intensive care unit length of stay in the presented study was 6.94 days but according to several studies from recent literature which reported the median intensive care unit length of stay was 7 days, with a range from 2 to 35 days[18].

Conclusion

This retrospective study is limited by the small sample size. Traumatic disruption of the thoracic aorta (TDTA) is an uncommon injury which requires aggressive diagnosis and treatment. TDTA can be found even if the patient has a normal chest radiography, and delayed treatment can lead to significant morbidity and/or mortality. The incidence of mortality rate from the operation to repair TDTA is significantly correlated with preoperative factors, particularly hypotension, associated injuries and the location of the aortic injury. The delay of operation in selective cases gives a better result than in the emergency cases. In the case of patients with an impending rupture or distal malperfusion, emergency surgical repair is required. The methods used in surgical repair and/or adjunctive distal perfusion vary in different forms. Distal circulatory perfusion is critical for effective spinal cord protection. Distal aortic perfusion and cross-clamp time are essential intraoperative factors to predict the incidence of spinal cord injury and postoperative paraplegia.

Adjunctive distal aortic perfusion to decrease the aortic cross-clamping must be maintained by using either cardiopulmonary bypass (CPB) or shunt with partial heparinization or heparinless centrifugal pump. Finally, a high level of suspicion and aggressive investigations to diagnose TDTA are necessary to avoid catastrophic results, and the decision to use surgical' strategies regarding the specific clinical situation.

Comment

It's generally accepted that TDTA has a high mortality and morbidity rate, although the patients received diagnosis and treatment. A high level of suspicion, accurate diagnosis, optimal time of surgery and surgical strategies can reduce the incidence of the mortality and morbidity rate.

The mortality rate was high in the present study, 3/5 of the dead patients had cardiac contusion which can effect myocardial function and increase the mortality rate.

The less experience with TDTA patients may be a disadvantage to increase the risk of postoperative paraplegia and the mortality rate. The authors found paraplegia in 2 patients, who presented with an aortic cross clamp time of than 40minutes. The alternative method to reduce postoperative paraplegia from the long duration of cross clamp time is by using an adjunctive distal perfusion. The authors prefer to use heparinization with adjunctive distal perfusion for TDTA patients without contraindications to reduce postoperative paraplegia.

A prospective study about factors which influence the mortality rate and factors related to postoperative paraplegia in TDTA patients is the authors' plans for developing the standard treatment or improving the quality of care for TDTA patients to decrease the mortality rate and the incidence of postoperative paraplegia in TDTA patients at Songklanakarind Hospital.

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ผลของการผ่าตัดผู้ป่วยที่มีภาวะเส้นเลือดแดงใหญ่ในช่องอกฉีกขาด ที่เข้ารับการรักษาในโรงพยาบาลสงขลานครินทร์

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การศึกษาแบบย้อนหลัง (retrospective study) ครั้งนี้ เก็บข้อมูลจากผู้ป่วยทั้งหมดที่มีภาวะเส้นเลือดแดงใหญ่ในช่องอกฉีกขาด (Traumatic Disruption of Thoracic Aorta : TDTA) ที่เข้ารับการรักษาในโรงพยาบาลสงขลานครินทร์ ตั้งแต่เดือนมีนาคม 2525 - เดือนกรกฎาคม 2546 จำนวน 11ราย เป็นเพศชาย 10ราย (ร้อยละ90.91) เพศหญิง 1ราย (ร้อยละ9.09) อายุเฉลี่ย 32 ปี ทุกรายได้รับการบาดเจ็บแบบ blunt injury จาก motor vehicle accident ไม่มีผู้ป่วยที่ได้รับการผ่าตัดเปิดทรวงอกที่ห้องฉุกเฉิน ได้รับการทำ chest X-ray ทุกราย ผลพบ widening mediastinum 10 ราย, hemothorax 8 ราย blurred aortic knob 7 ราย, lowering of left main bronchus 3 ราย, pleural apical cap 2 ราย และ pneumothorax 1 ราย ส่งทำ CT scan 8 ราย (ร้อยละ72.72) ให้ผลบวกทุกราย ส่งทำ CT scan และ aortogram 3 ราย พบ pseudo – false aneurysm กลุ่มตัวอย่างส่วนใหญ่คือ 10 ราย (ร้อยละ90.91) พบมีภาวะบาดเจ็บของระบบอื่นร่วมด้วย กลุ่มตัวอย่าง 7 ราย (ร้อยละ 63.64) มีภาวะ hypotention ตั้งแต่มาถึงโรงพยาบาลโดย 3 รายเสียชีวิตหลังการผ่าตัด และอีก 2 รายเกิดภาวะ paraplegia หลังผ่าตัด การผ่าตัดส่วนใหญ่ คือใน 6 ราย (ร้อยละ 54.54) ใช้วิธี clamp and sew technique ระยะเวลาของการทำ aortic cross clamp ในภาพรวมทั้งหมด ตั้งแต่ 19-67 นาที (เฉลี่ย 39.90 นาที) ภาวะแทรกซ้อนหลังผ่าตัดที่พบมากที่สุดคือ pneumonia 3 ราย (ร้อยละ27.27) รองลงมาได้แก่ ไตวาย, ARDS (เสียชีวิตทั้ง 2ราย) และ paraplegia อย่างละ 2 ราย โดยทั้ง 2 รายที่เกิด paraplegia ใช้ aortic cross clamp time มากกว่า 40 นาที ผู้ป่วย10ราย ได้รับการผ่าตัดฉุกเฉิน มี 1รายได้รับการผ่าตัดหลังจากวินิจฉัย 3 สัปดาห์เนื่องจากมีภาวะ severe brain contusion พบผู้ป่วยเสียชีวิต 5 ราย (ร้อยละ 45.45) โดยเสียชีวิตในห้องผ่าตัด 1 ราย และหลังผ่าตัด 24 ชั่วโมงแรก 4 ราย สาเหตุนำที่พบทั้ง 5 รายคือ ภาวะหัวใจหยุดเต้นขณะผ่าตัด นอกจากนี้ยังพบสาเหตุอื่นร่วมด้วย ได้แก่ ตกเลือดหลังผ่าตัด, ARDS และ ภาวะ arrhythmias ระยะเวลาเฉลี่ยของการอยู่ในหออภิบาลผู้ป่วยหนัก 6.94 วัน ระยะเวลาการอยู่โรงพยาบาลทั้งหมด 11-180วัน (เฉลี่ย 62.83วัน) การศึกษาครั้งนี้มีข้อจำกัดที่ขนาดของกลุ่มตัวอย่าง ผู้วิจัยจึงวางแผนที่จะศึกษาแบบไปข้างหน้า (prospective study) อย่างต่อเนื่อง โดยจะเจาะลึกในส่วนของปัจจัยที่สัมพันธ์และปัจจัยทำนายที่ทำให้ผู้ป่วยกลุ่มนี้เกิดภาวะ paraplegia หลังผ่าตัดและเสียชีวิต