Effectiveness of Transcatheter Arterial Embolization (TAE) for Massive Hemothorax

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Purpose

The gold standard treatment for massive hemothorax is emergency thoracotomy (ET). There are two main causes of massive hemothorax. One is intrapleural visceral injury and another is thoracic wall injuries such as subphrenic and intercostal arteries. However, to the latter injuries, we suggest the bleeding could be better controlled with Transcatheter Arterial Embolization (TAE) even with unstable vital signs. Recently, nonoperative managements are in discussion for the blunt trauma injury, but only with stable vital sign patients. The purpose of this study was to find out the effectiveness of TAE for unstable hemodynamic massive hemothorax caused by thoracic wall injuries.
Methods and Materials

Nine patients received TAE for ongoing massive hemothoracs in our trauma center during April 2004 to December 2009. These patients fulfill the indication of ET declared in Japan Advanced Trauma Evaluation and Care (JATECTM)[1]. JATECTM, the most common method to approach trauma patient in Japan, was derived from Advanced Trauma Life Support®, European Course Trauma Care, and Trauma Care® Manual. The indications of ET declared in JATECTM are as follows: a. initial chest drainage over 1000ml, or b. drained over 1500ml in first 1 hour, or c. drained over 200ml/hr for more than 2 hours, or d. continuous blood transfusion were required for stabilizing vital signs.

In patients who fit the indication of ET, if the systolic blood pressures (SBP) were maintained over 80 mmHg with massive infusion and blood transfusion, contrast enhanced computed tomography (CECT) were performed. Whether extravasations were detected or not, TAE were proceeded. Nine cases fitted this criteria. If the SBP was under 79 mmHg with massive infusion and blood transfusion, the standard treatment, ET, were performed and excluded from this study.

TAE were mainly performed by following procedures in our center. A four French introducer sheath were inserted into femoral artery and 4 Fr. Yashiro catheter, Michaelsson catheter were used to cannulate the main branches. Coaxial catheters were used to select peripheral artery to avoid embolizing Adamkiewicz artery. To decide which artery to investigate, CECT played an important role. If the extravasation was clear by CECT, the suspected arteries were cannulated and embolized. If the extravasation was unclear, intercostal arteries were investigated for extravasation from two rib bones above the fractured ribs to two bones below to make sure there are no anastomotic branches. If the fractured ribs were anterior component, internal thoracic artery was investigated too. Also subphrenic artery was investigated if the fractures were found in inferior ribs. When extravasations were found, TAE was performed using gelatin sponge particles.

The vital signs such as SBP, heart rate (HR), and shock index (SI) were collected from medical charts retrospectively. These data were recorded at following points: arrival, preTAE, postTAE 1 hour, and postTAE 6 hours. Also the infusions required to maintain stabilized vital signs were investigated. The average infusion volume (ml) per hour was compared between arrival to finishing TAE and finishing TAE to 24 hours from arrival to emergency room.

The statistical analyses were proceeded by using R 2.10.1.
Results

The characteristics of the nine patients are shown in Table 1. The mean age was 57.6 years (range: 19 to 82 years). The mean Injury Severity Score of nine patients was 28.44 ± 9.4 SD and all were over 16. The mean Revised Trauma Score was 6.65. Table 2 shows the indication of ET and the arteries embolized in each cases.

![Table 1: The characteristics of 9 patients](image)

**Fig.:** Table 1: The characteristics of 9 patients

**References:** Kameda Medical Center - Kamogawa/JP
Fig.: Table 2: The indication of ET and the arteries TAE were performed JATECTM indications of ET are A) initial chest drainage over 1000ml, or B) drained over 1500ml in first 1 hour, or C) drained over 200 ml/hr for more than 2 hours, or D) continuous blood transfusion were required for stabilizing vital signs.

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The results of the change in vital signs at four points were as follows (Figure 1, Table 3). The mean SBP improved from 81 mmHg at preTAE to 125mmHg at postTAE 1 hour (p = 0.02). The mean HR improved to 90 bpm at postTAE 6hours from 104 bpm at postTAE 1hour (p = 0.02) but no significant change between pre and postTAE 1 hour (p = 0.35). The mean SI also improved from 1.33 at preTAE to 0.85 at postTAE 1 hour although statistically not significant (p = 0.12). The mean infusion required to maintain stabilized vital signs reduced from 1234 ml/hr to 65 ml/hr (p = 0.007) (Figure 2).
Fig.: Figure 1: The changes of SBP, HR, SI in the mean HR did not improve much but SBP and SI improved significantly.

References: Kameda Medical Center - Kamogawa/JP
Table 3: The changes of SBP, HR, SI in the mean † SBP between preTAE and postTAE 1 hour was significantly improved. P = 0.02 ‡ Fluid required to maintain stabilized vital signs decreased. P = 0.007

References: Kameda Medical Center - Kamogawa/JP

<table>
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**Fig.**: Figure 2: Fluid required to maintain stabilized vital signs (ml/hr) dramatically decreased after TAE.

**References**: Kameda Medical Center - Kamogawa/JP

All nine patients (7 males, 2 females) had no intrapleural visceral injury. The causes of massive hemothorax were injuries of intercostal arteries, subphrenic artery, and internal thoracic artery. All nine patients survived and did not undergo any surgical intervention. No technical complications nor embolizing complications such as chest wall ischemia or paralysis were observed.

Case No.4 was a good example of the successful TAE stabilization for critically unstable patient by massive hemothorax due to a blunt trauma injury. (Figure 3 to 6).
Fig.: Figure 3: Outline of case No.4

References: Kameda Medical Center - Kamogawa/JP
Fig.: Figure 4: Contrast enhance CT of case No. 4 The arrows show the extravasations in intrapleural cavity (a, b) and the pelvic fractures (d). The arrow head shows the injury of liver. No extravasation were seen (c).

References: Kameda Medical Center - Kamogawa/JP
Fig.: Figure 5: Extravasation from the intercostal arteries were seen in the angiography and TAE were performed.

References: Kameda Medical Center - Kamogawa/JP
Fig.: Figure 6: Changes of vital signs in case No.4
References: Kameda Medical Center - Kamogawa/JP
### Cases

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<td>M</td>
<td>42/85.7</td>
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</table>

**Fig. 0:** Table 1: The characteristics of 9 patients

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Conclusion

There are few papers and case reports that mention the effectiveness of TAE for blunt and penetrating thoracic wall injury for its' being a minimally invasive and safe procedure. There are some case reports showing TAE might be effective even for massive hemothoraces [2, 3, 4]. The suggestion of angiography when the contrast enhanced CT shows contrast extravasation for blunt trauma has been mentioned [5]. The choice of TAE instead of ET for massive hemothoraces are still in argument. There are no clear indication for TAE yet.

All 9 patients survived in our study. TAE were successfully proceeded and were clearly effective to restrain hemorrhage and stabilize vital signs to ongoing massive hemothoraces. The causes of massive hemothoraces of all nine patients were diagnosed as thoracic wall injuries. We suggest that to the patients who can undergo CECT and intra-pleural visceral injury is ruled out, TAE could be an effective and less invasive treatment even for hemodynamically unstable patients with ongoing massive hemothoraces.

Surgical intervention team should be in standby during TAE in case TAE should fail to restrain hemorrhage.
References

1. Iwai (2010) Japan Advanced Trauma Evaluation and Care (JATEC) Guideline, 3rd edn. Health Publisher, Nakano Tokyo
Personal Information

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