Original Article

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Chest Tube Removal Time in Trauma Patients on Positive Ventilation Pressure: A Randomized Clinical Trial

Hamid Reza Abbasi[1], Farnaz Farrokhnia[1*], Sepideh Sefidbakht[1,2], Shahram Paydar[1], Shahram Bolandparvaz[1]

[1]Trauma Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.

[2]Medical Imaging Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.

Corresponding author: Farnaz Farrokhnia
Address: Trauma Research Center, Shahid Rajaei Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, Iran. Post code: 71345-1876 Tel: +98-711-6254206 Fax: +98-711-6254206
e-mail: abbasimezy@gmail.com

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ABSTRACT

Objective: To determine the removal time of the chest tube in ICU trauma patients under positive ventilation pressure (PVP).
Methods: This was randomized clinical trial being performed in ICU department of Rajaei trauma hospital from March to December 2011. A total number of 92 trauma patients who were admitted in ICU and were under ventilation and had chest tube were randomly assigned into two groups. In case group, chest tube was clamped after 5–7 days. In the control group, chest tube was retained until the patients were under PVP. The chest tube was removed if there was no air leak or the drainage was less than 300 mL.
Results: Complications observed in the case and control groups were 4.4% of 4.3% respectively (p=0.862). Among case group with hemothorax, 6.7% developed complication while this ratio for pneumothorax was 7.1% and zero in those with hemopneumothorax (p=0.561), whereas respective values for the control group were 11.1%, 8.3% and zero (p=0.262). Complications were noticed in 10.5% of those with more than 300 ml of pulmonary drainage. There were no complications in patients without air leak. In mild leak, 4.8% of subjects experienced complication, in moderate leak, no complication occurred and in severe ones, complication was visible in 7.7% of patients (p=0.842).
Conclusion: The present study showed that the removal of chest tube in patients under ventilation within 5-7 days after its insertion is safe without any complications.

Keywords: Chest tube; Removal time; ICU; Trauma; Positive ventilation pressure (PVP)

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Introduction

Currently, trauma is a major public health problem worldwide with a high morbidity and mortality both in developed and developing countries [1] and expected to rise dramatically by the year 2020 [2]. Thoracic trauma is still considered as one of the leading causes of morbidity and mortality in developing countries [3]. It comprises 10-30% of all traumas [4,5] and is directly responsible for 25% of trauma-related mortality and a contributing factor in another 25% [6]. The highest rates of trauma mortalities worldwide are reported in Eastern Mediterranean region while the World Health Organization (WHO) reported more than 300,000 deaths in 2008 (9% of all world deaths) [7]. Although the mechanism of injury traditionally does not alter chest tube management, complication rates may vary depending on the severity of injury [8].

Chest tube insertion is often used to manage pneumothorax, hemothorax and/or pleural effusion

Table 1. The mean of drainage of chest tube in those who underwent early versus late chest tube removal.

	Case (n=45)	Control (n=47)	*p*-value
Drainage after insertion (ml)	355.4 ± 30.7	410.6 ± 35.1	0.021
Drainage after 1 day (ml)	136.4 ± 13.3	154.5 ± 14.8	0.076
Drainage after 2 days (ml)	73.6 ± 28.6	99.4 ± 10.9	0.045
Drainage after 3 days (ml)	54.0 ± 17.6	47.5 ± 26.8	0.385
Drainage after 4 days (ml)	38.9 ± 19.3	45.1 ± 18.9	0.296

either due to a benign or malignant condition [5]. Thus, chest tube management and removal time are often dependent on the physicians' experiences and training [9]. Pneumothorax, hemothorax or empyema is the resulting causes of traumas leading to a collapse of the lungs and difficulty in ventilation [10-12]. The insertion of chest tube or performing thoracostomy may return the expansion of lungs and normal ventilation [13,14].

The removal time of chest tube from patients under ventilator is a controversial issue and is of great importance [15]. Some researchers reported that chest tube should remain in place until the patient is under ventilator [10] and some demonstrated that it should be removed as soon as possible [11]. It was shown that a positive pressure in ventilator may lead to a recurrent pneumothorax condition or a collapse in lungs [10], while some reported the contrary [12]. Although chest tube is a commonplace in patients injured by trauma or those who suffer from advanced stage of cancers in lung or pleura, there is few information on the best method for managing chest tube [9]. This study evaluated the chest tube removal time among ICU patients under ventilation in Martyr Rajaei Hospital, Shiraz, Southern Iran.

Materials and Methods

From March to December 2011, in a randomized clinical trial, 92 trauma patients including 80 males and 12 females and aged from 15–85 years referred to Martyr Rajaei Hospital affiliated to Shiraz University of Medical Sciences, Shiraz, Southern Iran underwent ventilation along with chest tube insertion. The patients were randomly divided into two groups. Patients on odd days were considered as case group (n=45) and those on even days as control group (n=47).

In the case group, the chest tube was maintained for 5-7 days and in the control group, it was present

Table 2. Complications after insertion of chest tube in both groups.

Group	**Patients**			**Control**		
Chest tube insertion	**Hemothorax No. (%)**	**Pneumothorax No. (%)**	**Hemo-pneumo thorax No. (%)**	**Hemothorax No. (%)**	**Pneumothorax No. (%)**	**Hemo-pneumo thorax No. (%)**
With complication	1 (6.7)	0 (0)	1 (7.1)	0 (0)	1 (8.3)	1 (11.1)
Without complication	14 (93.3)	16 (100)	13 (92.9)	26 9100)	11 (91.7)	8 (88.9)
***p*-value**	0.561			0.262		

Table 3. Complications of ventilation in both groups.

Group	**Patients**			**Control**		
Ventilation	Decreased GCS No. (%)	Pulmonary distress No. (%)	Decreased GCS+ pulmonary distress No. (%)	Decreased GCS No. (%)	Pulmonary distress No. (%)	Decreased GCS+ pulmonary distress No. (%)
With complication	0 (0)	2 (10.5)	0 (0)	0 (0)	0 (0)	2 (50)
Without complication	14 (100)	17 (89.5)	12 (100)	19 (100)	24 (100)	2 (50)
***p*-value**	0.23			0.001		

Table 4. Complications based on primary drainage in both groups.

Group	Patients		Control	
Primary drainage	≤300 ml No. (%)	>300 ml No. (%)	≤300 ml No. (%)	>300 ml No. (%)
With complication	0 (0)	2 (10.5)	1 (4.8)	1 (3.8)
Without complication	26 (100)	17 (89.5)	20 (95.2)	25 (96.2)
***P* value**	0.171		0.998	

until removing the ventilator from the patient. A questionnaire was provided to gather the demographic data of participants and was completed by general physicians of the hospital. In case group, the chest tube was clamped for 24 h after radiography and was under strict observation during this period. A second radiography was undertaken to determine the presence of any pneumothorax, hemothorax or pneumohemothorax, followed by re-opening the tube.

In the control group, radiography was done before removal of chest tube and the tube was clamped for 6 h. A second radiography was performed to evaluate the chest condition and if normal, the tube was removed. In absence of any air leak and liquid drainage of less than 300 ml during 24 hours, the chest tube was removed, considering all technical and ethical issues.

Patients with pulmonary masses, pulmonary interstitial diseases, major traumas to the chest and pneumonia were excluded from the study. A written consent was obtained from each patient and the study was approved by the University ethics committee. SPSS software (Version 11.5, Chicago, IL, USA) was used for statistical analysis. Fisher Exact and Pearson Chi Square tests were applied to compare the groups. *P* values less than 0.05 was considered statistically significant.

Results

Among the patients there were 80 (87%) men and 12 (13%) women. The mean age of the case group was 33.3±11.5 and that of the control group was 33.8±15.7 years (*p=0.532*). Fifty seven (62%) patients had trauma on the right side and 35 (38%) on the left side. Forty one (44.6%) patients had tubes due to hemothorax, 28 (30.4%) for pneumothorax and 23 (25%) for hemopneumothorax. The patients under ventilation comprised 33 subjects (35.9%) with decrease in Glasgow Coma Score (GCS) and 16 (17.4%) due to reduced GCS together with a pulmonary distress.

There was no air leak in 10 (10.9%) patients. Among 35 (93.8%) patients, the drainage was mild (induced by coughing); in 21(22.8%) cases moderate (occurred during speaking) and in 26 (28.3%) severe (noticeable during breathing). Those who underwent early removal of chest tube had significantly lower liquid drainage within 1st (*p=0.021*) and 3rd (*p=0.045*) days of removal (Table 1).

Among 92 participants, 23 (25%) subjects had hemothorax, 17 (18.4%) pneumothorax, 16 (17.4%) hemopneumothorax, 10 (10.8%) rib fracture and pneumothorax, 9 (9.7%) rib fracture and hemothorax, 7 (7.6%) rib fracture and hemopneumothorax, 6 (6.5%) clavicular and hemothorax, 2 (2.2%) clavicular and rib fracture together with hemothorax, 1 (1.1%) clavicular and rib fracture together with pneumothorax and 1 (1.1%) clavicular and rib fracture together with hemopneumothorax.

Complications were observed in 2 (4.4%) and 2 (4.3%) of the case and control groups respectively (*p=0.862*). Among the case group, one patient and among the control group, 2 were older than 50 years (*p=0.052*). As shown in Table 2, among the case group with hemothorax, 1 (6.7%) had complication, while this was evident in 1 (7.1%) patient with pneumothorax and none in hemopneumothorax. The respective figures for the control group were 1 (11.1%), 1 (8.3%) and zero.

As shown in Table 3, among patients under

Table 5. Complications based on air leakage in both groups.

Group	Patients				Control			
Air leak	None No. (%)	Mild No. (%)	Moderate No. (%)	Severe No. (%)	None No. (%)	Mild No. (%)	Moderate No. (%)	Severe No. (%)
With complication	0 (0)	1 (4.8)	0 (0)	1 (7.7)	0 (0%)	0 (0)	0 (0)	2 (15.4)
Without complication	4 (100)	20 (95.2)	7 (100)	12 (92.3)	6 (100)	14 (100)	14 (100)	11 (84.6)
***p*-value**	0.842				0.141			

ventilation due to pulmonary distress, complication was noticed in 2 (10.5%) subjects but none among patients with decreasing GCS and those with reduced GCS together with pulmonary distress. These figures for the control group were zero, zero and 2 (50%) ($p=0.001$).

Pulmonary drainage of less than 300 ml was noticed in 50% of patients in the case group. As demonstrated in Table 4, 2 (10.5%) patients with more than 300 ml of pulmonary drainage, developed complication and none exhibited in the subjects with less than 300 ml drainage. These figures in the control group were 1 (3.8%), and 1 (4.8%) ($p=0.05$).

There was no complication in patients without air leak. In mild leak, 1 (4.8%) subject experienced complication, in severe ones this was observed in 1 (7.7%) patient and in moderate leak no complication was noted. As shown in Table 5, in the control group, these figures were zero in negative, mild and moderate air leak whereas 2 (15.4%) patients experienced complication in severe air leak ($p>0.05$).

Discussion

Currently, trauma is one of the causes of mortality worldwide while chest trauma is the third cause of death next to head injury among trauma patients and usually affects young males in their productive period of life [16-18]. Clinical outcome of non-penetrating chest traumas vary from mild pain to lethal shocks and may be associated with rib fracture, hemothorax, pneumothorax and hemopneumothorax. The accumulation of air and blood in pleura can suppress pulmonary parenchyma and result in the collapse of lungs and irregular ventilation [16,19-21].

Thoracostomy is still the most widely performed procedure for management of blunt and penetrating chest traumas. Although it is a simple procedure, placing of a chest tube may be associated with several complications [22]. Recurrent air leak [23] and failure to evacuate blood from the pleural space [24] may lead to several undesirable sequelae such as hemothorax, pneumothorax, empyema and fibrothorax, requiring extended hospitalizations.

Chest tube insertion is considered as a therapeutic measure in these patients and the removal time of the chest tube is of great importance [25]. Robinson *et al.* reported the advantage of using chest tube until the end of ventilation [10]. In another study, no correlation was found between a positive ventilation pressure and the recurrent pneumothorax and collapse of the lungs [12]. In our study, the positive ventilation pressure did not influence the recurrence of pneumothorax and collapse of the lungs. In regard to complications such as hemothorax and pneumothorax, it seems there is no statistical difference between removing the chest tube from the patients under ventilation 5-7 days after insertion and its removal from the patients immediately after disconnection from the ventilator. Sadeghi *et al.* demonstrated that early removal of the chest tube could reduce the pain and the risk of pleural and pericardial effusion and empyema [11]. Abramov *et al.* noticed a better surgical outcome, without any complications and effusion, after an early removal of the chest tube and supportive therapy by administering analgesics, oxygen and physiotherapy [26]. Gottgens *et al.* showed that a long- lasting chest tube would increase the morbidities such as pain, discomfort, decreased activity, increased infection and duration of hospitalization. They demonstrated that early removal of chest tube can reduce the morbidities and complications [27]. Sienal *et al.* observed that the early removal of chest tube could significantly reduce these complications [28]. Russo *et al.* reported that early removal of the chest tube could significantly decrease the period of hospitalization and complications [29].

In regard to developing complications, we found that the removal of the chest tube from the patients under ventilation during a period of 5-7 days after its insertion did not statistically differ from chest tube removal from the patients exactly after disconnecting them from the ventilator.

In conclusion, the removal of chest tube in patients under ventilation within 5-7 days after its insertion is considered a safe method without any complication.

Conflict of interest: None declared.

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Original Article

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Modified Perihepatic Packing; A Creative and Beneficial Method for Management of High Grade Liver Injury

Sajjad Ebrahimi[1], Sedigheh Tahmasebi[1], Mohammad Reza Rouhezamin[1,2], Seyed Mohsen Mousavi[1,2*], Hamid Reza Abbasi[1,2], Shahram Bolandparvaz[1,2], Shahram Paydar[1,2]

[1]Trauma Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.

[2]Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran.

Corresponding author: Seyed Mohsen Musavi
Address: Trauma Research Center, Shahid Rajaei Hospital, Chamran Avenue, Shiraz, Iran.
Tel: +98-711-6254206 Fax: +98-711-6254206
e-mail: mohsenmousavi6788@gmail.com

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ABSTRACT

Objective: To evaluate the efficacy of modified perihepatic packing (MPHP) in reducing the rate of re-bleeding rate after packing removal.
Methods: This was an experimental study being performed in Shiraz animal laboratory. High grade liver parenchymal injury was induced in 30 transgenic Australian rabbits which were then divided into two groups. Group A (control) included 14 and group B (experimental) comprised 16 rabbits. The animals in group A underwent standard perihepatic packing (SPHP) and those in group B were subjected to MPHP. Re-bleeding was assessed and compared between the two groups, after removal of perihepatic packings.
Results: There was no significant difference between two study groups regarding baseline and perioperative characteristics. Rabbits in group A had significantly lower rate of postoperative re-bleeding compared to those in group A (57.1% vs. 12.5%; p=0.019). The mean bleeding volume was also significantly lower in group B compared to group A (76.88 ± 22.12 vs. 98.93 ± 33.8 mL; p<001). Although the survival rate was higher in group A compared to group B (93.8% vs. 78.6%) but the difference was not statistically significant (p=0.315).
Conclusion: MPHP is a simple and safe procedure for surgical management of high grade liver parenchymal injury concomitant with severe loss of glisson's capsule. This procedure significantly decreases re-bleeding after packing removal in comparison with SPHP.

Keywords: High grade liver injury; Perihepatic packing (PHP); Modified perihepatic packing (MPHP)

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Introduction

Trauma is one of the most common life-threatening injuries and among the most prevalent causes of death worldwide. In this context, the abdominal trauma has always been a complicated problem of patients. The trauma to the liver, whether penetrating or blunt, is considered as one of the most common abdominal injuries, which leads to death or high morbidity. Conservative management of patients with trauma to the liver has evoked remarkable interest and led to progressive achievements in recent years. The indications for operative management of liver injuries are laparotomy for penetrating injury, patient's instability, or concomitant internal injury [1]. Those with major hepatic injury, however, often develop hemodynamic instability and therefore operation would be the method of choice for them. Among various methods of liver bleeding control, perihepatic packing has become the most successful procedure. This method is performed to achieve quicker hemostasis by placing surgical pads

around the liver to pack it, so that the wound will be compressed against the pads and between the anterior chest wall, diaphragm, and retro peritoneum [1].

The conventional surgical procedures for management of liver injury are midline incision, primary packing, clot removal and bleeding control. The bleeding of small injuries can be managed by surgical methods and medications. These include finger fracture [1,2], administration of inappropriate haemostatic agents, suturing, fibrin derivatives and in more complicated cases, lobar resection [1,3,4] and liver transplantation [1,5,6]. Unlike low grade liver trauma, the management of high grade (grade III to V) liver trauma is a challenging problem for many trauma surgeons, especially in patients with coagulopathy, acidosis and hypothermia. In presence of high grade liver injury, the patients are usually hemodynamically unstable. Furthermore, manipulation of liver by the surgeon may exacerbate the patient`s condition. In these situations damage control surgery (DCS) is the most reasonable approach to cope with liver trauma [1,2].

Perihepatic packing (PHP) has previously been assessed as a method for DCS in liver trauma. The studies revealed lesser complications when PHP is used appropriately [1,3,5,7,8]. The most important goal of this method, as well as other DCS procedures, is the correction of acidosis, coagulopathy and hypothermia [5]. But there is no study which clearly states the indications of perihepatic packing and its proper duration. Close observation after primary packing, and the need for an experienced surgeon to manage the second surgery are the other shortcomings of this method [3,8]. But because of its simplicity, PHP is available and widely used. In this method, the entire liver surface is packed all around [5] after resection of as many ligaments as needed to immobilize the liver. The patient will be monitored in ICU after the surgery. After correction of acidosis, coagulopathy and hypothermia the patient will undergo the second surgery to remove perihepatic packs.

Some of the complications of this method are sepsis, vascular collapse and re-bleeding after packs removal [3]. Hemobilia and bilovenous fistula are other rare complications of PHP [1,2,9,10]. Packing duration is a controversial issue. Theoretically, 24 to 48 hours is needed to correct acidosis, coagulopathy or hypothermia. On the other hand, the longer the packing time, the higher the risk of sepsis. Less than 7% of complications of liver trauma surgery are due to bleeding. Abdominal swelling, detection of low blood pressure and high pulse rate are signs of re-bleeding. In this condition stable patients can be treated with percutaneous procedures but unstable cases should undergo open surgery to stop bleeding.

The mortality rate of traumatic liver injury is about 10-15%. Type of injury and damage to adjacent organs are factors affecting the mortality rate. Mortality rate of a penetrating trauma to liver only is about 1%, whereas that of hepatic blunt trauma could be as high as 20% [1,2,9,10]. Furthermore, when the liver is the only injured organ, the mortality rate is about 10%, but the injury of two other organs beside liver, increases the mortality rate to about 70% [9,10]. The aim of this study is to evaluate the efficacy of modified perihepatic packing (MPHP) in reducing the rate of re-bleeding rate after packing removal.

Materials and Methods

Animals

All animals were chosen, prepared and handled according to the Ethics committee guidelines. Having approved by a statistician and with reference to relevant studies, 32 genetically homologous, healthy white Australian rabbits (weighing about 10 kg) of either sex with hemodynamically stable condition were obtained from an animal breeding center of Shiraz University of Medical Sciences, as a pilot study, considering ethic limitations imposed on many animal experiments for medical reasons In Iran. However, the bilobar, right-lobe dominant liver of these rabbits was comparable with those of humans, and similarities in consistency, shape, anatomic relations and perihepatic ligaments. Furthermore, the vascular structures and liver segments were also similar to human liver, in number and anatomy.

The exclusion criteria were unhealthy general appearance, abnormal weight, pregnancy, unstable hemodynamics and death during the first surgery or one hour post-surgery. Two animals were later excluded from the study after laparotomy, because of the operation room being unprepared for one rabbit and the pregnancy for another. The remaining 30 rabbits which met the inclusion criteria had become nil per os (NPO) since 6 hours prior to the operation.

Surgical procedure

After a preoperative visit by a vet, the animals were anesthetized with Terazol (6 mg) and Glycopyrrolate (0.1mg), getting intubated and receiving intravenous maintenance fluid followed by close monitoring for blood pressure, pulse rate and O_2 saturation during and one hour post-surgery. The hemodynamic status was intermittently monitored for 48 hours post-surgery. For fluid management, a venous access was established under general anesthesia through a triple lumen (5Fr) placed in external jugular vein. After insertion of the triple lumen, 100-200 ml

dextrose saline was administered initially, and 10-20ml/kg/hr of the same solution were infused as the maintenance fluid.

After the routine prep and drape, the rabbits underwent a midline abdominal incision. To expose the liver, 2 or 3 lowest right ribs were removed and all the perihepatic ligaments hindering access to all surfaces of the liver were cut but vascular structures were preserved. After the exposure of the liver in the surgery field, it was covered with some sterile gauze. The weight of gauze soaked and saturated with blood after induction of trauma to the liver determined the pretreatment blood loss. The injury was induced by a laceration, made with a clamp, and equivalent to the grade IV to V liver parenchymal injury, according to American college of surgeons of trauma classification. The clamp penetrated deeply in the parenchyma of the right lobe of the liver and was displaced toward the inferior vena cava (IVC) to form a 4 in 5 cm star-shaped wound. After primary bleeding control, the wet gauze around the liver was removed, blood clots were collected and surgery field blood was suctioned. These three components determined the pretreatment amount of bleeding. After 15 seconds of bleeding, the rabbits were divided into two groups by flipping a coin. Bleeding was controlled primarily by direct pressure of the surgeon`s finger. In group B (case group), the liver injury was managed by MPHP. The surface of the injured liver was covered with a haemostatic agent (surgicel) followed by wrapping up the liver with a water proof, nonstick plastic. The entire surface of the liver was covered except the liver hilum. The liver was then packed counterclockwise from 6 to 5 to spare the hilum. After MPHP, the surgery field was observed for 15 minutes to detect bleeding. In cases with no bleeding, the abdomen would be closed. Finally, after one hour of observation, the dead rabbits were excluded from the study whereas the living animals were transported to their cages. During the surgery, the animals' blood pressure was maintained above 70 mmHg with fluid administration through the IV access.

In group A (control group), injury induction, primary bleeding control with pressure of the surgeon`s finger and measuring pretreatment blood loss were the same as group B. Contrary to group B, the liver injury was managed with counterclockwise packing of the liver without application of surgical or covering the liver with water proof plastic. The post-op observation and the criteria to transport the animals to their cages were the same as group B.

In both groups, after initial surgery, the surviving animals were observed for 48 hours. The dead animals in the cage period underwent an exploratory laparotomy to detect the cause of probable bleeding. These animals were included in the death group due to re-bleeding.

The survivors of the first surgery underwent the second operation after 48 hours for assessment of post-treatment bleeding and detection of possible re-bleeding. Post-treatment bleeding was considered as the amount of blood loss (clots, suctioned blood, and wet pads weight) detected in the second surgery after opening of abdominal cavity. To assess re-bleeding, the liver was observed and watched closely enough to detect any hemorrhage after removal of the packs. Subsequently, to make sure that there was no hemorrhage, the liver was rinsed with normal saline very gently for 15-30 minutes and the injured site was observed for fresh re-bleeding. Totally, detection of 5ml or more fresh blood in the field was considered as significant re-bleeding. In our study, total bleeding (TB) was determined by summation of blood loss during pre-treatment, post treatment and re-bleeding. After the second surgery, the rabbits were sacrificed according to Ethics committee guideline.

Statistical analysis

Normal distribution of two groups was assessed with Kolmogorov-Smirnov test. *P*-value was calculated with Fisher's and chi-square tests for re-bleeding rate after the surgery, total bleeding volume and survival rate. The average amount of total bleeding in two groups was also compared suing independent t-test. A 2-sided *p*-value less than 0.05 were considered statistically significant.

Results

A total of 32 white Australian rabbits met the inclusion criteria while 2 were further excluded from the study. Thus the final number of rabbits was 30 being randomized to two study groups (group A= 14 rabbits and group B=16 rabbits). The study

Table 1. Comparison of study outcomes between those rabbits that underwent standard (group A) or modified (group B) perihepatic packing.

	Group A (n=14)	Group B (n=16)	*p*-value
Survival Rate (%)	11 (78.6%)	15 (93.8%)	0.315
Re-bleeding Rate (%)	8 (57.1%)	2 (12.5%)	0.019
Bleeding amount (mL)	98.93 ± 33.8	76.88 ± 22.1	<0.001