

Intrahepatic Balloon Tamponade for Penetrating Liver Injury: Rarely Needed but Highly Effective

Lisa M. Kodadek¹ · David T. Efron² · Elliott R. Haut²

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Abstract

Background Severe penetrating liver injuries are associated with high rates of morbidity and mortality. The objective of this study was to demonstrate the 15-year experience of a Level 1 US trauma center with use of intrahepatic balloon tamponade for penetrating liver injuries in adult patients.

Methods Operative notes were used to identify cases employing intrahepatic balloon tamponade. Charts were reviewed for patient characteristics, injury characteristics, morbidity, and in-hospital mortality.

Results Of the 4961 penetrating trauma patients admitted during the study period, 279 (5.6%) had liver injury and underwent exploratory laparotomy. Intrahepatic balloon tamponade was attempted in nine patients (3.2%). Two of the nine patients (22%) were in cardiac arrest at time of balloon placement and died during the index operation; both had retrohepatic IVC injury combined with cardiopulmonary injury. In patients who reached the operating room alive and had spontaneous circulation at the time of balloon placement, utilization of this technique was associated with 100% survival.

Conclusion Although rarely needed, trauma surgeons must be prepared to use intrahepatic balloon tamponade as one surgical technique to control major hepatic injuries.

Background

Penetrating liver injuries are associated with significant hemorrhage and high rates of morbidity and mortality. Traditional techniques for controlling hepatic hemorrhage may include Pringle maneuver, hepaticotomy with vascular ligation, hemostatic agents, and temporary packing (i.e., damage control surgery). These routine approaches will successfully control hemorrhage in most patients. However, for central hepatic injuries, particularly when deep or transfixing both lobes of the liver, these techniques may not provide sufficient hemorrhage control. Trauma surgeons may find these injuries challenging to manage, and alternative approaches may be necessary. The objective of this study was to demonstrate the experience of a single institution with intrahepatic balloon tamponade for control of hemorrhage from penetrating liver injuries.

✉ Elliott R. Haut
ehaut1@jhmi.edu

Lisa M. Kodadek
lisa.kodadek@vumc.org

David T. Efron
defron1@jhmi.edu

¹ Department of Surgery, Vanderbilt University School of Medicine, 1211 Medical Center Drive, Nashville, TN 37232, USA

² Department of Surgery, Johns Hopkins University School of Medicine, Sheikh Zayed 6107C, 1800 Orleans St., Baltimore, MD 21287, USA

Method

This retrospective study queried the trauma registry of a single urban Level 1 US trauma center. Patients aged 16 years and older with penetrating traumatic liver injury (ICD-9 864.00-864.19) admitted between 2000 and 2015 were included. Operative notes for all patients with traumatic liver injury who underwent exploratory laparotomy (procedure code 54.11, 54.12, 54.19) were reviewed. Cases employing intrahepatic balloon tamponade with any type of balloon device were identified. These cases of interest were then reviewed for patient demographics, injury characteristics including liver injury grade, adjunct procedures, blood product utilization, morbidity, and in-hospital mortality. This study was reviewed and approved by the institutional review board of the hospital conducting the study.

Results

Among 4961 penetrating trauma patients admitted during the study period, 279 (5.6%) had liver injury and underwent exploratory laparotomy. Operative notes for these 279 cases were individually reviewed in order to identify the use of intrahepatic balloon tamponade in nine patients (3.2%). Patient, injury, and hospital course variables for these cases are presented in Table 1. Liver injury was secondary to gunshot wounds (eight patients) or stab wounds (one patient). Seven patients had grade V liver injury, and two patients had grade IV injury. Seven cases (77.8%) utilized a Penrose drain/red rubber catheter balloon (Fig. 1), and two cases utilized a Foley catheter balloon. The balloon tamponade device was used in

Table 1 Intrahepatic balloon tamponade: patient, injury, and hospital course variables

Variable	Incidence/value
Sex (male)	9 patients (100%)
Age (mean)	24.3 ± 4.8 years
ISS (mean)	32.8 ± 6.3
Liver injury severity	
Grade IV	2 patients (22%)
Grade V	7 patients (78%)
Initial systolic blood pressure (mean)	90.7 ± 43.0 mm Hg
Red blood cell transfusion, index case (mean)	14.7 ± 9.9 units
Duration of balloon tamponade (mean, survivors)	3.4 ± 1.7 days
Duration of open abdomen (mean, survivors)	4.1 ± 3.4 days
Duration of hospital stay (mean, survivors)	28.1 ± 23.7 days
Mortality	2 patients (22%)

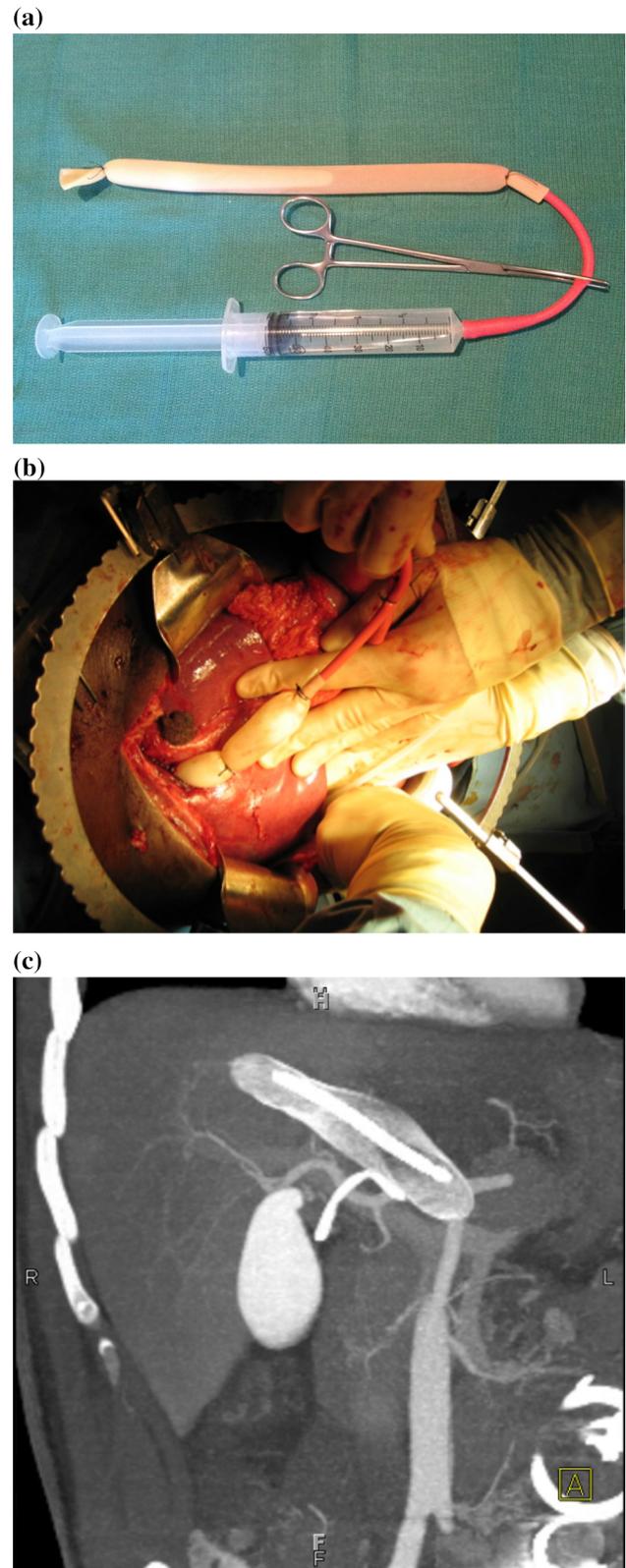


Fig. 1 Penrose drain/red rubber catheter. **a** Balloon device consists of 12 French red rubber catheter and 1-inch Penrose drain, **b** balloon device deployed within penetrating hepatic injury tract, and **c** balloon device deployed, computed tomography image

conjunction with other standard techniques for control of liver hemorrhage including Pringle maneuver, packing, argon beam coagulation, suture ligation, and total hepatic isolation. One patient had the balloon immediately removed for increased hemorrhage after placement. Two of the nine patients (22%) were in arrest at time of balloon placement and died during the index operation. Both patients who died had retrohepatic IVC injury combined with severe cardiopulmonary injury.

Among the seven survivors, the mean duration of balloon tamponade was 3.4 days and mean duration of open abdomen was 4.1 days. All survivors required a second operation for removal of the balloon tamponade device and closure of the abdomen. Adjunctive procedures included hepatic angioembolization for definitive hemorrhage control (three patients, 43%), and endoscopic retrograde cholangiopancreatography (ERCP) stenting for biliary injury (two patients, 29%). Two patients (29%) developed liver abscess requiring drainage. One patient, temporized with balloon tamponade, ultimately required a staged left hepatectomy in the setting of liver abscess and associated bowel obstruction 2 weeks after the index operation. In patients who reached the operating room alive and had spontaneous circulation at the time of balloon placement, utilization of this technique was associated with 100% survival.

Discussion

A limited number of prior case series or reports have highlighted the use of intrahepatic balloon tamponade for hemorrhage control in penetrating liver injury [1–5]. Mortality in these series is as high as 61%, and morbidity is significant with reported complications including biliary fistula, biliary peritonitis, and abscess. The current findings are similar to those reported by Ball and colleagues who used balloon tamponade for liver injury in 12 patients with 67% survival [1]. However, in this series, a Blakemore balloon was used most commonly (58%) and the Penrose drain/red rubber catheter was used in only 33% of cases. Similarly, two of the patients who died had retrohepatic venous injury and also required atriocaval shunt. In a large series from Brazil, 46 patients underwent hepatic tamponade with a Blakemore balloon [2]. Mortality in this series was similar (24%) to our findings, and morbidity was significant (56.5%). The Penrose drain/red rubber balloon tamponade device and the Blakemore balloon have both been used for the purpose of hepatic hemorrhage control with reported success. However, the Penrose/red rubber device is easily constructed with readily available basic equipment and does not require access to a more

specialized Blakemore balloon. The Penrose/red rubber device may be a more effective option in resource-limited settings.

Although rarely needed, trauma surgeons must be prepared to use intrahepatic balloon tamponade as one surgical approach to control hepatic injuries. This approach is useful in situations when a patient's physiology or concomitant injuries preclude immediate exposure and repair of hepatic hemorrhage or hepatic resection. While most liver injuries are now managed with nonoperative approaches or angioembolization, surgeons must be familiar with various techniques to address liver injury in the operating room. The first approach to control hepatic hemorrhage at time of laparotomy is perihepatic packing. The falciform and coronary ligaments are divided to allow for mobilization of the liver and placement of laparotomy pads above and below the liver in the cranio-caudal plane. If packing is unable to control hemorrhage, a Pringle maneuver is utilized to control hepatic inflow. The Pringle maneuver is performed by placing a vascular clamp or a Rummel tourniquet across the porta hepatis. This maneuver allows the surgeon to distinguish hepatic venous and retrohepatic inferior vena cava injury from portal venous and hepatic arterial injury. If the extent of injury is minimal and peripheral, argon beam coagulation, deep suture ligation with zero chromic sutures on a blunt-tip needle, or hemostatic packing agents may be sufficient. Deeper injuries may require hepatotomy with sequential firing of a linear stapling device or a bipolar vessel sealing device. For central hepatic injuries, particularly when deep or transfixing both lobes of the liver, these techniques may not provide sufficient hemorrhage control. The surgeon may then assess the injury tract and determine whether balloon tamponade may be a suitable treatment option.

The components of the balloon tamponade device are basic and widely available. A 12 French red rubber catheter and a 1-inch Penrose drain are used to assemble the device (Fig. 1a). Either end of the Penrose is secured with 0-silk suture. The deflated device is placed within the liver parenchyma via the missile tract. Finally, a syringe with either normal saline or saline mixed with contrast is used to inflate the balloon (Fig. 1b). The device may remain in place for several days to allow for resuscitation and physiologic stability (Fig. 1c). Although subsequent complications are common and adjunct procedures including angioembolization and biliary stenting are often required, intrahepatic balloon tamponade may prove expedient for the successful initial control of hemorrhage.

This study is one of the largest series of balloon tamponade for penetrating liver injuries in the USA. Although limited by its highly descriptive nature and small cohort of cases without controls, this study demonstrates successful use of a surgical technique in a challenging group of

injured patients. Uncommon, but critically important, surgical techniques like these are ideal targets for simulation training and may be of use in settings with limited resources.

Conclusion

Although rarely needed, trauma surgeons must be prepared to use intrahepatic balloon tamponade as one effective technique to control major hepatic injuries. This procedure can result in survival even after major penetrating liver injury.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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