Case Report

Pulmonary embolism in two patients after severe hepatic trauma

Joanne K. Claveria^{a,*}, Michael T. Meyer^a, Martin K. Wakeham^a and Thomas T. Sato^b

^a*Division of Pediatric Critical Care Medicine, Children's Hospital of Wisconsin, Medical College of Wisconsin, Milwaukee, WI, USA*

^b*Division of Pediatric Surgery, Children's Hospital of Wisconsin, Medical College of Wisconsin, Milwaukee, WI, USA*

Received 25 January 2013

Revised 25 February 2013

Accepted 26 February 2013

Abstract. Patients with severe hepatic trauma requiring damage control laparotomy and perihepatic packing are at risk for venous thromboembolism (VTE). Prevention and treatment of VTE in this population is problematic, especially in children for whom adult guidelines are often adapted. The following case report describes two children who developed VTE with associated pulmonary embolism after damage control laparotomy and perihepatic packing for hepatic trauma. The first patient had hemodynamically significant pulmonary emboli. He received catheter-directed thrombolysis with subsequent improvement in ventilation and need for inotropic support. The second patient had a vena caval thrombus detected on surveillance ultrasound and later developed a pulmonary embolus, both of which were treated with heparin and enoxaparin. Our experience suggests that surveillance imaging of these patients may allow for prospective mobilization of specialized resources, such as interventional radiology support or cardiopulmonary bypass equipment, and that catheter-directed thrombolysis may be a viable treatment modality in these critically ill and injured children.

Keywords: Pulmonary embolism, venous thromboembolism, thrombolytic therapy, tissue plasminogen activator, perihepatic packing, hepatic trauma

1. Introduction

Among adult and pediatric patients with severe liver trauma, damage control laparotomy with perihepatic packing has become an accepted method to achieve hemostasis during the initial resuscitation. Complications of this strategy include venous thromboembolism (VTE), abdominal compartment syndrome, and hemodynamic compromise. These patients will likely have

some element of reduced blood flow in the retrohepatic cava, predisposing them to vena caval thrombus. The incidence of VTE in adult and pediatric patients with severe hepatic trauma is unknown. However, there have been at least two case reports of adults who developed significant VTE within days after undergoing perihepatic packing [1,2]. Given the critical condition and bleeding risk in these patients, the best method to prevent and treat VTE poses unique challenges.

We report the identification and treatment of VTE associated with pulmonary embolism (PE) in two children with severe liver trauma requiring damage control laparotomy with perihepatic packing and delayed abdominal closure. Successful treatment of these

*Corresponding author: Joanne K. Claveria, Division of Pediatric Critical Care Medicine, 1775 Dempster Steet Park Ridge, Illinois, 60068, USA. Tel.: +1 847 723 5313; Fax: +1 847 723 2325; E-mail: joanne.claveria@advocatehealth.com.

patients required individualized, multidisciplinary therapy adapted from available adult data and guidelines. The following cases of VTE in children with hepatic trauma present important clinical questions. What are the appropriate strategies to prevent VTE and monitor for thrombosis in severe liver trauma patients who require perihepatic packing and staged operative procedures? What is the role of thrombolysis in critically ill, injured children with coagulopathy and clinically significant thrombus? Until specific pediatric criteria and treatment guidelines are established, the use of currently available adult guidelines for VTE management may represent the best available care.

2. Case reports

2.1. Case 1

A 17-year-old male with hepatic and right renal lacerations from a gunshot wound to the right upper quadrant. He arrived in hemorrhagic shock and underwent emergent damage control laparotomy with perihepatic packing for exsanguinating hemorrhage from the liver and retrohepatic veins. Postoperative abdominal computed tomography (CT) demonstrated a grade five hepatic injury involving >75% of the right hepatic lobe, the right portal vein, and the right and middle hepatic veins. Removal of abdominal packing, segmental hepatectomy, and ligation of the right portal venous branches were performed on hospital day three. Upon removal of the packing, he developed acute hypoxemia that responded to increased ventilatory support. He subsequently developed increasing dead space ventilation, hypoxia, and hemodynamic instability requiring inotropic support. Contrast enhanced chest CT demonstrated PE involving the right main pulmonary artery, right upper and lower lobe arteries, and segmental branches of the lingula and left lower lobe (Fig. 1). An echocardiogram showed evidence of right ventricular strain.

Given the patient's bleeding risk and clinical instability, the decision was made to proceed with catheter-directed thrombolysis using recombinant tissue plasminogen activator (tPA). Under fluoroscopy, a catheter was inserted through the left subclavian vein with the tip seated in the right pulmonary artery. tPA was infused at 30 mg/h for two hours, giving a total dose of 60 mg. This dose between 22 mg and 90 mg was chosen given the patient's weight of 70 kg, and because 22 mg is the maximum adult dose for intra-arterial tPA therapy

Fig. 1. Arrows indicate bilateral pulmonary emboli in case 1.

for thrombotic stroke [3] and 90 mg is the maximum adult dose for systemic intravenous tPA used to treat acute thrombotic stroke [4]. Treatment was infused over two hours, the typical interval cited in the guidelines for intra-arterial thrombolysis [3]. During thrombolytic therapy, the patient required blood product transfusions for significant bleeding from his chest tube, intravenous catheter sites, and surgical drains. After completing the tPA infusion, the patient was treated with an unfractionated heparin infusion. Repeat echocardiogram showed improved right ventricular strain. Inotropic support was discontinued two days after thrombolytic therapy, and the patient was eventually discharged home on warfarin.

2.2. Case 2

A 6-year-old male pedestrian with severe blunt abdominal trauma from motor vehicle collision. Injuries included a grade five liver injury involving the left main portal vein, left hepatic artery, and inferior vena cava (IVC). Damage control laparotomy with perihepatic packing was performed. On hospital day eight, trauma protocol-based Doppler ultrasound – from this institution's adaptation of adult protocols – revealed extensive thrombus from the infrarenal IVC to the right common femoral vein. This was the site of a previous central venous catheter. Given the need for further procedures and the risk for bleeding from surgical drains, an unfractionated heparin infusion was instituted and titrated to a partial thromboplastin time of 40–60 sec. Once all anticipated procedures were complete, the patient transitioned to enoxaparin treatment. On hospital day 25, CT imaging for workup of fevers revealed

Fig. 2. Arrow indicates right sided pulmonary embolism in case 2.

an asymptomatic PE (Fig. 2). The patient's enoxaparin dose was readjusted and he eventually transitioned to warfarin therapy prior to discharge home.

3. Discussion

The best method for preventing, monitoring and treating VTE children with severe liver trauma is controversial since there is little pediatric data available and the incidence of VTE in children is less than in adults. This leads to the adoption of adult guidelines for severely ill and injured children. According to current adult trauma guidelines, VTE prophylaxis in severe liver trauma would likely be limited to intermittent pneumatic compression devices and/or use of vena cava filter (VCF) until contraindications for pharmacologic prophylaxis resolve. However, it is suggested that VCF not be used as primary prophylaxis. The adult data show that VCFs probably cause as many deep vein thrombosis as PE events prevented, and they carry at least 5% risk of other serious complications [5]. Use of temporary VCF may be considered, but positioning of the VCF remains challenging with risk for migration, since the VCF would need to be positioned in the suprahepatic IVC. While reported experience with VCF in children is promising, the use of prophylactic VCF in critically injured children remains unclear, and is therefore not widely utilized [6].

Surveillance monitoring for deep vein thrombosis in patients with severe liver trauma may be useful in planning treatment of VTE, despite the unclear utility of surveillance ultrasound in reducing VTE-associated morbidity and mortality in adults. We have adapted

and implemented for children one widely published adult trauma protocol incorporating surveillance ultrasound [7]. Our institution has previously reported a VTE incidence of 6.2% in injured children requiring intensive care, diagnosed at a median of nine days post-admission; two-thirds of the VTEs were associated with a previous or existing central venous catheter [8]. Therefore, surveillance ultrasound for VTE identification in critically injured children, particularly those with central venous catheters, would seem prudent. While magnetic resonance venography is recommended for diagnosing catheter-related VTE, image acquisition time may be prohibitive in an unstable, injured child [9].

In children with clinically significant hepatic trauma, requiring damage control laparotomy and packing, definitive IVC thrombosis recognition may be difficult given the altered anatomy from the injuries and the imaging artifact introduced by the packs. However, hepatic packing effective to stop hemorrhage from extensive parenchymal or retrohepatic venous injury may predispose to IVC thrombosis, warranting an increased index of suspicion for VTE in these patients. Consequently, CT imaging prior to removal of hepatic packing may allow clinicians to identify IVC thrombosis. Recognition of significant caval thrombosis allows for prospective mobilization of other resources, including interventional radiology support and cardiopulmonary bypass equipment. Alternatively, intraoperative snaring of the IVC prior to packing removal may be performed, but thrombus has likely already formed and operative maneuvers in this anatomic area may be treacherous. Retrohepatic IVC thrombus is, in part, what prevents lethal hemorrhage in severe hepatic trauma. In one report of VTE associated with perihepatic packing, intraoperative ultrasound incidentally demonstrated a major IVC thrombus extending to just above the renal vessels. That patient was successfully treated with percutaneous mechanical thrombectomy and IVC filter placement [1].

While critically ill and injured children with life or limb-threatening thrombosis may warrant thrombolysis or thrombectomy, there is little evidence-based consensus for employing such therapies. Providers are limited by bleeding risk, lack of specialized equipment and resources at individual institutions, and an overall paucity of experience in pediatric patients. Percutaneous endovascular thrombectomy has been described in case reports of children with acute ischemic stroke and PE [10–12]. Another therapeutic option for patients at high risk for bleeding may be catheter-directed thrombolysis. Our cases were hospitalized prior to the publication of the most recent VTE

guidelines for children in 2012 [13]. Those guidelines recommend tPA for thrombolysis in pediatric patients and they report the most commonly cited intravenous dosing regimen in the pediatric literature. However, there are no strong data to support one regimen over others, nor are there data to suggest the superiority of either intravenous (i.e. systemic) or catheter-directed thrombolysis. Age-related differences in efficacy of tPA and potential need for co-administration of fresh frozen plasma must also be considered since infants have less plasminogen than older children. The massive PE in case 1 was treated with catheter-directed thrombolysis and was complicated by transfusion-manageable bleeding. It resulted in subsequent ventilation and hemodynamic improvements. His dosing regimen was adapted from intra-arterial and systemic tPA regimens used in adults with thrombotic stroke. Case 2 was anticoagulated since he had no clinical indications for thrombolysis.

Children with severe liver trauma requiring perihaptic packing are at risk for VTE and have limited options for prophylaxis and treatment. As such, these children may benefit from ultrasound surveillance. If VTE were found or strongly suspected prior to the onset of limb or life-threatening symptoms, providers may consider further imaging with CT, mobilize specialized resources, and consider the use of catheter-directed thrombolysis or endovascular thrombectomy. Until studies that are more rigorous have been done to guide evidence-based therapies and protocols in pediatric patients with VTE, the use of adapted adult guidelines may represent the best care available.

References

- [1] John TG, Chalmers N, Redhead DN, Kumar S, Garden OJ. Case report: inferior vena caval thrombosis following severe liver trauma and perihaptic packing-early detection by intraoperative ultrasonography enabling treatment by percutaneous mechanical thrombectomy. *Br J Radiol* 1995;68(807):314–7.
- [2] Waltensdorfer A, Mahla E, Zink M, Oberwalder P, Mischinger HJ, Metzler H. Central pulmonary artery embolism after perihaptic packing because of liver trauma. *J Trauma* 2007;63(3):E81–4.
- [3] IMS Study Investigators. Combined intravenous and intra-arterial recanalization for acute ischemic stroke: the Interventional Management of Stroke Study. *Stroke* 2004;35(4):904–11.
- [4] Albers GW, Amarenco P, Easton JD, Sacco RL, Teal P. Antithrombotic and thrombolytic therapy for ischemic stroke: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest* 2004;126(3 Suppl):483S–512S.
- [5] Gould MK, Garcia DA, Wren SM, Karanicolas PJ, Arcelus JJ, Heit JA, et al. American College of Chest Physicians. Prevention of VTE in nonorthopedic surgical patients: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest* 2012;141(2 Suppl):e227S–77S. Erratum in: *Chest* 2012;141(5):1369.
- [6] Kukreja KU, Gollamudi J, Patel MN, Johnson ND, Racadio JM. Inferior vena cava filters in children: our experience and suggested guidelines. *J Pediatr Hematol Oncol* 2011;33(5):334–8.
- [7] Cuschieri J, Freeman B, O'Keefe G, Harbrecht BG, Bankey P, Johnson JL, et al. Inflammation and the Host Response to Injury Collaborative Research Program. Inflammation and the host response to injury a large-scale collaborative project: patient-oriented research core standard operating procedure for clinical care X. Guidelines for venous thromboembolism prophylaxis in the trauma patient. *J Trauma* 2008;65(4): 944–50. Erratum in: *J Trauma* 2009;66(3):965.
- [8] Hanson SJ, Punzalan RC, Greenup RA, Liu H, Sato TT, Havens PL. Incidence and risk factors for venous thromboembolism in critically ill children after trauma. *J Trauma* 2010;68(1):52–6.
- [9] Chalmers E, Ganesen V, Liesner R, Maroo S, Nokes T, Saunders D, et al. British Committee for Standards in Haematology. Guideline on the investigation, management and prevention of venous thrombosis in children. *Br J Haematol* 2011;154(2):196–207.
- [10] Sur JP, Garg RK, Jolly N. Rheolytic percutaneous thrombectomy for acute pulmonary embolism in a pediatric patient. *Catheter Cardiovasc Interv* 2007;70(3):450–3.
- [11] Menon SC, Hagler DJ, Cetta F, Cabalka AK. Rheolytic mechanical thrombectomy for pulmonary artery thrombus in children with complex cyanotic congenital heart disease. *Catheter Cardiovasc Interv* 2008;71(2):237–43.
- [12] Tsivgoulis G, Horton JA, Ness JM, Patterson D, Brethour M, Abanes JC, et al. Intravenous thrombolysis followed by intra-arterial thrombolysis and mechanical thrombectomy for the treatment of pediatric ischemic stroke. *J Neurol Sci* 2008;275(1–2):151–3.
- [13] Monagle P, Chan AK, Goldenberg NA, Ichord RN, Joumneycake JM, Nowak-Göttl U, et al. American College of Chest Physicians. Antithrombotic therapy in neonates and children: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest* 2012;141(2 Suppl): e737S–801S.