CASE CONFERENCE

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Section Editors

CASE 0—2014

Inferior Vena Cava Compression by Retroperitoneal Hematoma During Cardiopulmonary Bypass

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CARDIOPULMONARY BYPASS (CPB) first was applied successfully in cardiac surgery by John H. Gibbon in 1953.1 Since that clinical milestone more than 60 years ago, CPB has evolved into a mainstream technique in contemporary cardiac surgery to facilitate open- and closed-chamber procedures of all types, including specialized perfusion approaches such as deep hypothermic circulatory arrest.2 The safe conduct of CPB requires a vigilant and experienced team approach to minimize serious errors and to solve critical events when they occur.3 This conference presents a challenging case of major retroperitoneal hemorrhage that presented during CPB. The successful detection and management of this rare but serious complication is outlined, highlighting the principles of a team approach, vigilance, and creative applications of transesophageal echocardiography. The case conference begins with a description and discussion of the case, followed by 2 expert commentaries, the first from the cardiac surgeon’s perspective and the second from the cardiac anesthesiologist’s perspective.

CASE PRESENTATION*

A 56-year-old man with a history of prior coronary artery bypass grafting presented with fever and reduced effort tolerance. During his hospital admission, transthoracic echocardiography revealed aortic valve vegetations with severe aortic regurgitation. Despite appropriate antibiotic therapy, the patient remained very symptomatic, even after blood cultures became negative. After extensive discussion, the patient agreed to undergo aortic valve replacement.

After uneventful induction of general anesthesia and institution of full invasive monitoring, comprehensive transesophageal echocardiography (Phillips Healthcare, Andover, MA) showed aortic valve vegetations, severe aortic regurgitation, significant central mitral regurgitation, and normal biventricular function.

Before commencement of repeat sternal entry, a right femoral arterial catheter (20 gauge × 5 inches, Arrow International, Reading, PA) was placed percutaneously using standard Seldinger technique with guidance from anatomic landmarks. Multiple passes with a 20-gauge needle were required in the ultimately successful placement of the femoral arterial catheter. In light of the challenging cannulation of the right femoral artery, the right axillary artery was exposed to serve instead as the arterial cannulation site for cardiopulmonary bypass (CPB).4 Subsequent sternotomy and mediastinal exposure were completed without incident. After adequate systemic heparinization was confirmed, CPB was initiated via an axillary arterial cannula and a right atrial venous cannula.

Within the first hour after initiation of CPB, significant reduction in venous return to the CPB reservoir developed, accompanied by acute anemia requiring serial blood transfusion to maintain the hematocrit above 21%. These clinical events initiated a systematic search for the etiology. Surgical inspection of the operative field found no sources of bleeding. Interrogation of the thoracoabdominal aorta by transesophageal echocardiography (TEE) ruled out acute dissection and/or rupture. Furthermore, the tip of the atrial venous cannula was confirmed by surgical palpation and TEE to be within the proximal inferior vena cava (IVC). During the careful evaluation of the IVC by TEE, significant compression of the IVC by a perihilar hematoma was detected (Fig 1 and Video clip 1).

These findings prompted immediate exploratory laparotomy with right retroperitoneal exposure, which found an arterial bleed from the posterolateral wall of the right external iliac artery without arterial dissection. The arteriotomy was repaired successfully and the retroperitoneal hematoma was evacuated. Subsequent comprehensive examination with TEE showed

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decompression of the inferior vena cava with normalization of the bloodflow pattern (Fig 2 and Video clip 2).

The patient was weaned from CPB after aortic valve replacement and mitral valve repair. After a structured and detailed handoff to the intensive care unit team, the postoperative recovery was uneventful. The patient was discharged successfully from the hospital with appropriate arrangements for ongoing intravenous antibiotic therapy for his endocarditis. The case also was discussed and reviewed in depth at the cardiac multidisciplinary clinical effectiveness and quality improvement meeting involving the cardiac surgeons, cardiac anesthesiologists, perfusionists, and perioperative nursing management.

DISCUSSION

The differential diagnosis of low venous return during CPB includes hypovolemia, vasodilation, and/or obstruction (Table 1). Hypovolemia in this setting may be secondary to venous bleeding, arterial bleeding, cardiac chamber disruption, and/or vigorous diuresis. As this case illustrates, significant hemorrhage may be concealed and, therefore, not readily apparent. Besides the abdominal cavity, the chest cavity at times also may be the location of concealed large hematoma, such as bleeding into the left pleural cavity after harvest of the left internal mammary artery.

Vasodilation in this intraoperative setting may be secondary to medications, inflammatory mediators, and anaphylaxis. Preoperative exposure to angiotensin blockers such as angiotensin-converting enzyme inhibitors and/or angiotensin-receptor blockers is an established risk factor for significant vasoplegia during cardiac surgery with CPB and noncardiac surgery. In the setting of refractory vasoplegia during CPB, low-dose vasopressin infusion should be considered for hemodynamic rescue for restoration of vascular tone and venous return. In this case, the acute anemia suggested a bleeding source rather than systemic vasoplegia. Furthermore, there was no major evidence for anaphylaxis, such as a trigger medication, bronchospasm, or cutaneous rash. Septic shock was a possible etiology for vasoplegia in this case, given the established diagnosis of endocarditis and large vegetation.

Table 1. Differential Diagnosis of Low Venous Return During Cardiopulmonary Bypass

<table>
<thead>
<tr>
<th>Category</th>
<th>Sources of bleeding</th>
<th>Etiologies</th>
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<tbody>
<tr>
<td>Hypovolemia</td>
<td>Sources of bleeding</td>
<td>Etiologies</td>
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<tr>
<td></td>
<td>Thoracic cavity</td>
<td>Hypovolemia</td>
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<td>Abdominal cavity (intra- and retroperitoneal)</td>
<td>Hypovolemia</td>
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<td>Extremities</td>
<td>Hypovolemia</td>
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<td></td>
<td>Cannula disconnection</td>
<td>Hypovolemia</td>
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<td></td>
<td>Cannulation sites</td>
<td>Hypovolemia</td>
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<td></td>
<td>Arterial line sites</td>
<td>Hypovolemia</td>
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<td>Venous line sites</td>
<td>Hypovolemia</td>
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<td></td>
<td>Vigorous diuresis</td>
<td>Hypovolemia</td>
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<tr>
<td>Vasoplegia</td>
<td>Medications</td>
<td>Hypovolemia</td>
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<td></td>
<td>Angiotensin blockers</td>
<td>Hypovolemia</td>
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<td>Calcium channel blockers</td>
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<td>Nitroglycerin infusion</td>
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<td>Volatile anesthetics</td>
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<td>Intravenous anesthetics</td>
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<td>Anaphylaxis</td>
<td>Hypovolemia</td>
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<td>Inflammatory mediators</td>
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<td>Obstruction</td>
<td>Septic shock</td>
<td>Hypovolemia</td>
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<td></td>
<td>Systemic inflammatory response</td>
<td>Hypovolemia</td>
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<td>Venous reservoir-to-patient height differential</td>
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<td>Inadequate negative pressure within venous reservoir</td>
<td>Hypovolemia</td>
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<td>Vascular: intrinsic</td>
<td>Hypovolemia</td>
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<td>Venous valves (eg, Eustachian valve)</td>
<td>Hypovolemia</td>
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<td></td>
<td>Emboli (eg, tumor, thrombus)</td>
<td>Hypovolemia</td>
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<tr>
<td></td>
<td>Vascular: extrinsic</td>
<td>Hypovolemia</td>
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<td>Inferior vena cava compression: Abdominal compartment syndrome</td>
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<td>Retroperitoneal hematoma</td>
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<td>Superior vena cava compression: Mediastinal hematoma</td>
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<td>Right atrial compression: Pericardial hematoma</td>
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Circulatory obstruction as an etiologic category of low venous return during CPB can be divided into etiologies related to the CPB hardware and/or etiologies related to native vascular compression. The suboptimal performance of the venous drainage cannula for CPB may be responsible for poor venous return during CPB. Mechanical venous obstruction may occur because of malposition, such as cannula migration from the inferior vena cava into a major hepatic vein or from the superior vena cava into the azygos vein. Significant resistance to venous flow may follow kinking of cannulae that have a smaller caliber and/or that are inserted peripherally. Further etiologies in the CPB circuit include reduced height differential between the patient and the venous reservoir and inadequate negative pressure on vacuum-assisted venous drainage.

Native vascular obstruction may occur due to intrinsic and extrinsic factors. Intrinsic causes of vascular occlusion are due to the impediment of luminal blood flow through the venous system, ultimately including the cannula tip. These include occlusion from tumor, thrombus, air, and tissue structures such as long Eustachian valves. Extrinsic vascular obstruction also may follow compression from hematoma, whether pericardial (atrial collapse), retroperitoneal (inferior vena caval collapse), or mediastinal (superior vena caval collapse).

Retroperitoneal hemorrhage is a rare complication of femoral arterial cannulation. The genesis of a retroperitoneal hematoma in this setting typically is related to the arterial puncture of the posterior wall of the femoral artery either above or below the inguinal ligament. Blood may track into the retroperitoneum along the posterior wall of the femoral sheath. The risk of this complication is higher when the posterior wall arteriotomy involves the external iliac artery compared with the femoral artery. The brisk bleeding from an arteriotomy of a major peripheral artery can be exacerbated by systemic heparinization, which can be accompanied by abdominal distention, retroperitoneal hematoma, and spread to the perihepatic and perisplenic areas. The retroperitoneum can accommodate large blood volumes, thus making tamponade of the bleeding source in this setting a delayed feature. The retroperitoneum is a major venous reservoir or collection chamber for venous return due to retroperitoneal hematoma. Prompt TEE diagnosis allowed rapid surgical intervention and subsequent hemostasis evacuation, with echocardiographic evidence illustrating the return of normal blood flow.

EXPERT COMMENTARY: THE CARDIAC SURGEON’S PERSPECTIVE†

The presented case is that of a perihepatic hematoma with ensuing intraoperative exploratory laparotomy during CPB for valve surgery. This is a very rare occurrence and provides opportunity for discussion of the potential causes and options for management of decreasing venous return during CPB. Briefly, the patient was undergoing reoperation after previous coronary artery grafting. Although landmark guidance and the Seldinger technique were used for the femoral arterial catheter, multiple needle passes were required. Once CPB was initiated, the team noted acute anemia, despite transfusion. A diagnostic search including TEE revealed perihepatic hematoma with venous caval compression. During exploratory laparotomy, a bleeding right external iliac artery was repaired, with resolution of the clinical events, and the case proceeded without incident.

Retroperitoneal hematomas (RPH) have been documented after femoral access in percutaneous coronary interventions, but rarely in cardiac surgical cases. In the literature, retroperitoneal hematoma typically is secondary to pelvic trauma or femoral catheterization, with an incidence of 0.15% to 0.5% during percutaneous coronary intervention. Large retrospective studies have shown a low incidence (0.4%-2%) of intra-abdominal complications after CPB, including retroperitoneal hematoma. To the best of the authors’ knowledge, there are only 3 previously reported cases of intraabdominal bleeding during CPB requiring urgent laparotomy. These reports suggest that an early diagnosis of retroperitoneal hematoma is difficult to establish, with late signaling features such as unexplained anemia and/or falling venous return on CPB being the norm. Abdominal compartment syndrome, decreased urine output, or increased hepatic enzymes also may be signs of retroperitoneal hematoma. These clinical criteria, however, remain insensitive for diagnosis of complications after cannulation of the femoral artery.

As illustrated by this case, retroperitoneal hematoma during CPB is typically a complication caused by accidental puncture of the posterior wall of the iliofemoral arterial segment, aggravated by concomitant systemic heparinization. The blood then may track into the retroperitoneum via the posterior femoral sheath. Furthermore, retroperitoneal hematoma also may occur spontaneously as a complication of heparin therapy.

In the setting of CPB, when a significant drop in hemoglobin or blood volume is encountered, potential causes should be explored systematically by the operative team, including the surgeons, anesthesia providers, and perfusionists. The first step should be to investigate for causes of decreased venous return due to cannula malposition (or migration) or venous reservoir-to-patient height differentials. Obstruction

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also may stem from embolic phenomena (thrombus, fat, air), or obstruction of the cannula due to IVC or SVC compression. If these causes are eliminated, the team should consider blood loss from surgical sites, cannulation sites, and excessive diuresis. If these causes are excluded, the team should consider the impact of any vasodilatory medications, the systemic inflammatory response, and/or possible anaphylactic/anaphylactoid reactions.

If no sources of overt bleeding are recognized, the surgeon should consider all sites of vascular puncture as potential bleeding sources. A significant amount of volume may be trapped within the retroperitoneum, and as such, the diagnosis of RPH may be challenging.

One of the best modalities for assessing a retroperitoneal bleed is TEE. TEE has been shown to have good specificity and sensitivity (75% and 100%, respectively) in identifying hematomas, but is also highly operator-dependent. TEE also is useful to examine for occult sources of blood loss. TEE should be performed systematically, first examining for evidence of blood in the mediastinum, specifically, surrounding the posterior structures, such as the abdominal aorta and esophagus. The position of all venous cannulae, axillary lines, and internal jugular lines should be confirmed with TEE and also assessed for any collection of blood.

If TEE is unavailable and an intraabdominal source of blood loss is suspected, a small incision can be made in the subxiphoid diaphragm to explore the abdomen. Once a diagnosis of retroperitoneal hematoma is established, initial management may be conservative, consisting of crystalloid fluid resuscitation or blood transfusion. Studies have shown that in a hemodynamically stable patient, conservative management alone is adequate. In the setting of CPB, there are no specific guidelines to suggest when to intervene with endovascular or open surgery to stop the bleeding. All efforts should be made to complete the procedure, terminate CPB, and reverse the heparinization. If this is not possible or if the patient’s resuscitation requirements persist, general surgery and vascular surgery teams should be called for immediate assistance. Studies have shown that intraabdominal complications with CPB have a high mortality rate (13%-100%), and quick resolution of the issue is essential.

Failing conservative treatment, exploratory laparotomy should be initiated. Endovascular approaches may be applicable if performed by an experienced surgeon with appropriate equipment. Currently, there is no high-quality randomized trial showing the benefit of open surgery versus endovascular techniques. After the cause of decreased venous return is resolved, the cardiac surgical team should make the decision to either finish the initial procedure expeditiously or discontinue bypass and transfer the patient to the intensive care unit (ICU). Factors such as patient stability, patient risk factors, and the ability of the patient to withstand another cardiac surgery should be considered in the surgeon’s decision-making algorithm. In the ICU, the patient should be observed for the next 48-72 hours for hemodynamic instability, occult blood loss, and potential abdominal compartment syndrome. After the patient is taken to the ICU, it is important to have a team debriefing session and a structured detailed handoff to minimize errors in the postoperative management of this unusual complication during CPB. Here, each member of the team should be allowed to voice any concerns and also recognize which steps were carried out well and which steps require further discussion.

Retroperitoneal hematoma is a rare, but serious, complication during cardiac surgery. Preventive strategies include meticulous catheter insertions, with minimal traumatic percutaneous entry into the vessel. Femoral arterial catheters may be placed with ultrasound guidance. In a recent randomized trial (n = 1,004), the authors concluded that routine ultrasound guidance improved cannulation of the common femoral artery, and also reduced the number of attempts, time to access, risk of venipunctures, and vascular complications. In another study, the authors identified that first-attempt success rate during arterial cannulation is higher when using ultrasound guidance versus landmark and palpation alone. The Society of Cardiovascular Anesthesiologists vascular access guidelines does not recommend routine ultrasound imaging for arterial cannulation but does acknowledge that this modality aids in identifying the location and patency of suitable arteries. Additionally, ultrasound vascular imaging provides confirmation of the guidewire placement to reduce complications, including inadvertent arterial dissections. A recent international expert evidence-based recommendation also supported the beneficial roles for ultrasound imaging in arterial cannulation.

The present case described a rare but serious complication during CPB. Retroperitoneal hematoma is difficult to diagnose, and the surgeon should have a high index of suspicion when issues with venous return or signs of abdominal distention occur. Possible preventative strategies include use of ultrasound-guided catheter placement and limiting needle attempts. This case, along with the other discussed published reports, identify the importance of TEE imaging in the evaluation of decreased venous return during CPB. Once the diagnosis of retroperitoneal hematoma is made, it is important to have good team communication, and, if necessary, collaboration with other surgical teams to allow for rapid intervention and resolution of the issue. Because such occurrences are rare, it is important to have debriefing sessions with the team and establish clear protocols to both prevent and manage any future episodes.

EXPERT COMMENTARY: THE CARDIAC ANESTHESIOLOGIST’S PERSPECTIVE‡

This report raises the following questions for the cardiac anesthesiologist, which will form the basis for this expert commentary: (1) What are the hemodynamic consequences and management of reduced venous return during CPB? (2) How can the TEE examination facilitate the evaluation of reduced venous return in CPB? (3) Is there a role for perioperative transabdominal ultrasonography in this case? (4) Is there a role for ultrasound guidance to obtain arterial access?

During CPB for cardiac surgery, venous blood is drained from large-bore cannulae into a venous reservoir connected to the heart-lung machine. Maintenance of normal flows to

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perfuse end-organs during CPB requires sufficient volume in the venous reservoir. During CPB, it is not unusual to hear the perfusionist report that the venous reservoir volume is dropping. Arterial outflow may be lowered temporarily to avoid introducing air into the bypass circuit, but this should not be considered a long-term solution. Although oxygen consumption is lowered in patients cooled on CPB, prolonged low-flow states may cause end-organ ischemia and potentially permanent injury. As mentioned in this report, there are a large number of etiologies for poor venous drainage. The recognition of venous drainage issues should prompt a systematic investigation performed in parallel by the surgical, anesthesia, and perfusion teams. If the perfusionist continues to have dangerously low volumes in the venous reservoir, then crystalloid or blood products must be added to preserve circulating vascular volume.

The surgery team should visually and manually assess cannula position to correct inadequate drainage of the venous system. The anesthesiologist may use echocardiography to help assess proper venous cannula position and function. This is particularly important in the case of minimally invasive surgery, because the surgeon may not be able to manually detect malposition. An echocardiographer should be able to interrogate various cannulation strategies, which are determined by the planned cardiac surgical procedure. It is important to understand the basic types of cannulation, which include bivacal, single atrial, and cavo-atrial, to correctly assess cannula position and evaluate the surrounding structures. Several echocardiographic views are helpful to assess the superior vena cava (SVC), inferior vena cava (IVC), and right atrium (RA) for cannula position. The midesophageal bivacal view is helpful to visualize the junction of the SVC and IVC with the RA. This view also will help identify structures that may impede cannula drainage. In addition, this view can achieve good position of peripherally inserted drainage cannulae within the right atrium. Cannulae positioned within the RA may have flow obstructed by the interatrial septum. Visualization of the IVC/RA junction is important, because the Eustachian valve has been reported to obstruct IVC cannula drainage, and changing cannula position can relieve the obstruction. Migration of the IVC cannula into a hepatic vein may reduce venous return and can be detected by TEE. Visualization of the IVC cannula position within the IVC can be obtained by rotating the TEE probe slightly to the right from the four-chamber view and advancing the probe. This view can show IVC cannula position within the hepatic IVC. To further evaluate the IVC cannula position in the hepatic IVC long axis, the multiplane should be adjusted to approximately 90 degrees. Color Doppler may be used to assess drainage capabilities of venous cannulae and may assist in diagnosing partial obstruction by demonstrating turbulent high velocity flow. Doppler velocities within the cannula may be obtained, but little data exist on normal values and will not aid in detecting the cause of the poor drainage.

The surgery team can examine the open chest cavity, including the pleural spaces. If the pleural spaces are not formally opened, then the anesthesiologist should visualize them with TEE. Occasionally, the pleural cavity is unintentionally accessed, and blood will collect within this space undetected by the surgeon. In addition, examination of the pockets of the drapes may reveal pooling of blood from bleeding sources that were thought to be insignificant. The anesthesiology team and nursing should look carefully underneath the drapes to rule out bleeding from other sources such as catheter puncture sites or an inadvertently opened stopcock connected to an intravascular catheter. Finally, the abdomen and legs should be evaluated for hematoma, and a high index of suspicion for retroperitoneal hematoma should be maintained for patients with femoral vessel access.

The physicians in this case were able to make the diagnosis of retroperitoneal hematoma with the aid of TEE. As discussed earlier, this is one of the few reports in the literature of retroperitoneal hematoma during CPB. This complication is rare after percutaneous coronary intervention, and even rarer in cardiac surgery, judging from the paucity of published reports. Gaining catheter access to femoral arteries during cardiac surgery can be challenging, especially during the actual bypass period. In addition, the bleeding associated with arterial puncture may go unrecognized and track into the retroperitoneal space as described in this report. The lack of reports describing this complication may be a sign that this is an unrecognized complication that is difficult to diagnose in the operating room setting.

Computed tomography is the study of choice for evaluation of the abdomen and pelvis for hematoma but is not readily accessible in most operating rooms. A limited physical examination of the abdomen may be performed by the surgeon, but the sensitivity of this examination is limited at best. Kirkpatrick et al reported that clinical abdominal examination had a sensitivity of 56% for significantly elevated intra-abdominal pressure. The classic signs of retroperitoneal hemorrhage including periumbilical ecchymoses (Cullen sign) or flank ecchymoses (Grey-Turner sign) will be hidden by the sterile drapes and do not present immediately. Obvious abdominal distention may not be present unless the patient sustains massive bleeding. This leaves ultrasound examination as a readily available alternative for diagnosis.

TEE has been proven useful as a monitoring and diagnostic tool for cardiac surgery and has evolved in the hands of experienced practitioners from a routine assessment tool to a multi-use diagnostic tool. The systematic examination of structures in the chest has been well described and formalized into guidelines, but examination of abdominal structures is less strictly defined. TEE examination of the abdomen has been shown to be useful in select procedures. TEE in the hands of an experienced practitioner can visualize the abdominal aorta and inferior vena cava for cannula position and wire placement. Identification of individual abdominal structures and Doppler evaluation of bloodflow may be challenging. Yang et al attempted to evaluate left renal blood flow in 60 patients undergoing cardiac surgery using pulse-wave Doppler. The researchers were not able to visualize the kidney in 3 patients, and 20 patients had Doppler angles ≥30 degrees, which can cause significant error in the value of calculated blood velocity. Oishi et al reported a success rate of 100% in visualizing the celiac artery with TEE, but only a 92.5%, 66.7%, and 66.7% success rate with the superior mesenteric artery, left renal artery, and right renal arteries, respectively.
This report also raises the question of how to reliably use ultrasound in the operating room to diagnose abdominal compartment syndrome due to retroperitoneal hematoma. Visualization of the hematoma by ultrasound helps to confirm the diagnosis, but ultrasound examination of the abdomen is not 100% sensitive in detecting retroperitoneal hematoma. In this report and the report by Yamaura et al, the clinicians noted collections of blood adjacent to the liver. The hematoma in this report included images of hyperechoic collections of blood surrounding the liver, whereas Yamaura et al described hyperechoic and hypoechoic blood collections. Hyperechoic collections may indicate unclotted blood and hyperechoic collections may indicate clotted blood. One important point that should be noted is that the presence of an abdominal fluid collection or blood clot may not be obvious to all perioperative echocardiographers. To recognize an abnormal finding, clinicians must first be able to recognize normal findings. Since abdominal organ imaging is not part of the standard TEE examination, it might be difficult for most practitioners to notice a new fluid collection or hematoma.

The use of intraoperative epicardial echocardiography has expanded the armamentarium of the anesthesiologist to include a surface ultrasound probe. These probes are now used to image the heart in patients in whom a TEE probe cannot be placed or visualization with a TEE probe is impaired. Anatomy that may be better visualized with a surface probe includes anterior cardiac structures and the proximal aortic arch. In addition, anesthesiologists trained in critical care medicine are using ultrasound to examine the abdomen. The availability of ultrasonography may tempt the clinician to examine the abdomen in a patient in whom bleeding is suspected, but the retroperitoneal space may be difficult to visualize with a surface probe.

Finally, the question arises of how to reduce the risk of bleeding complications associated with femoral arterial access. Ultrasound now is used regularly to guide venous central line access and reduces the time to cannulation and the risk of complications. A recent randomized trial (n = 1004) of femoral arterial cannulation found that ultrasound guidance significantly improved first-pass success rate (83% v 46%, p < 0.0001), reduced number of attempts (1.3 v 3.0, p < 0.0001), and lessened vascular complications (1.4% v 3.4% p = 0.04). The authors did note that practitioners who had greater experience with ultrasound had a high success rate with cannulation. In the authors’ experience, there is a learning curve to using ultrasound to guide vascular cannulation, and infrequent use on difficult patients may not reduce complication rates.

The paucity of reports describing retroperitoneal hematoma in cardiac surgery patients may indicate that there is no need for a systematic TEE examination of the abdominal cavity unless there is a suspicion of a collection. But it is impossible at this time to comment on the ability of most perioperative echocardiographers to recognize retroperitoneal hematoma if confronted with the need for a diagnosis. The increasing use of femoral vessel access with minimally invasive cardiac surgery may increase the risk of bleeding complications associated with femoral artery access in these cases. Increasing the awareness of the etiology, associated signs, and diagnosis of this vascular access complication may help the cardiac team confronted with this rare problem.

In conclusion, this case conference illustrates effective rescue from a rare complication in CPB, based on prompt recognition, team-based comprehensive evaluation, confirmation with TEE, and effective surgical intervention. Cohesive teamwork with clear communication remains essential in the perioperative care of the cardiac patient.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1053/j.jvca.2013.10.020.

REFERENCES