Management of spontaneous and iatrogenic retroperitoneal haemorrhage: conservative management, endovascular intervention or open surgery?

Y. C. Chan,¹ J. P. Morales,¹ J. F. Reidy,² P. R. Taylor¹

Introduction

Little has been written about retroperitoneal haemorrhage since its first description fifty years ago (1,2). It is a well-recognised but relatively rare condition, with an incidence of 0.1% in a series of 2012 patients, although it may be as high as 0.6% in patients receiving oral anticoagulant therapy (3). Retroperitoneal haemorrhage is now most frequently seen as a complication of femoral artery catheterisation and pelvic or lumbar trauma. It may occur in ruptured abdominal aortic or iliac aneurysms or trauma, discussion of which is beyond the scope of this article. Rarely, it may be caused by rupture of renal or mesenteric aneurysms (4–8) or ovarian artery aneurysms (9). Bleeding can occur from underlying causes in any of the retroperitoneal structures, such as the pancreas (10), adrenal glands (11) or kidneys (5). It may also occur as a complication of any retroperitoneal surgery, which may be open or laparoscopic (12). Retroperitoneal haemorrhage may also occur as a complication of image-guided procedures (13). It can happen spontaneously, without any obvious precipitating factors, so-called spontaneous retroperitoneal haematoma. This is seen most commonly in patients who are anticoagulated or who are on haemodialysis. Diagnosis is often delayed because of the lack of specific presenting symptoms. Cutaneous manifestations of haematoma with Grey-Turner or Cullen signs are late signs of retroperitoneal haematoma.

Survival of the patient often depends on rapid and accurate diagnosis, as the bleeding may be insidious.
and unrecognised initially. Even if patients do not die of shock and rapid exanguination immediately, they may die later of complications of compartment syndrome. This is often caused by large retroperitoneal haematoma in patients undergoing anticoagulation therapy (14). Once this complication has developed, decompression of the abdomen by means of a laparostomy is the treatment of choice.

Spontaneous retroperitoneal bleed

Spontaneous retroperitoneal bleeding is a distinctive clinical entity that can present in the absence of specific underlying pathology or trauma (15). Isolated case reports exist in the literature stating that spontaneous retroperitoneal haemorrhage may occur without any precipitating factors, such as spontaneous haemorrhage into a pre-existing benign adrenal cyst or bleeding from a left inferior phrenic artery (16). Spontaneous bleed can occur in patients with factor IX or factor X deficiency (17), in patients with von Willebrand disease (18), or in patients with antiphospholipid syndrome (19). Rarely, spontaneous retroperitoneal haematoma may develop if the patient is on clopidogrel (20).

It is most commonly seen in association with patients with anticoagulation therapy, bleeding abnormalities, and haemodialysis (21), and may represent one of the most serious and potentially lethal complications of anticoagulation therapy (Fig 1). The incidence of retroperitoneal haematoma has been reported at 0.6–6.6% of patients undergoing therapeutic anticoagulation (3,22,23). Warfarin, unfractionated and low-molecular weight heparin have all been implicated (24). The risk of bleeding during unfractionated heparin therapy has been estimated to be two- to fivefolds greater than that with warfarin (25). In a review of 51 cases of patients receiving unfractionated heparin and developing spontaneous retroperitoneal haematoma, most of their coagulation parameters were in the therapeutic range (26). The risk of low-molecular weight heparin causing retroperitoneal haematoma is often increased if the patient is also receiving long-term warfarin. The elderly patients, and those with renal failure on dialysis are also at risk (27–29). In general, patients maintained on chronic haemodialysis have an increased incidence of spontaneous bleeding from various parts of the body, especially if they are receiving heparin or warfarin (30).

The pathophysiology and pathogenesis of spontaneous retroperitoneal bleeding remain unclear. It has been hypothesised that diffused occult vasculopathy and arteriosclerosis of the small vessels in the retroperitoneum may render them friable and therefore prone to rupture, although such theories have not been substantiated on histology (31). Qanadli et al. (32) postulated that spontaneous bleeding starts at the microvascular level, and large vessels become disrupted or stretched as the haematoma enlarges. Others have suggested that heparin- or anticoagulation- induced immune microangiopathy may be
Management of retroperitoneal haemorrhage

Though the term spontaneous implies the lack of observable injury, many authors have suspected that unrecognised trauma (such as minor trauma in sports and vomiting or coughing) may initiate blood loss which continues unabated when clotting factors are absent or depleted. In a retrospective study of 12 patients undergoing anticoagulation therapy who developed large rectus sheath haematoma, six patients had a history of coughing fits (34). Such minor trauma is a recognised inciting factor in haemophilia-related spontaneous retroperitoneal bleed (35–37).

Iatrogenic retroperitoneal bleed

Retroperitoneal haematoma secondary to percutaneous vascular access was first described in 1963, when the aorta ruptured after trans-lumbar aortography (38). Percutaneous vascular access using the Seldinger technique has undoubtedly improved the safety of intra-arterial procedures (39). Retroperitoneal haematoma following cardiac catheterisation is an infrequent but significant complication with a worldwide incidence of 0.15% (40), but the true incidence may be higher as most cases are under-reported or unrecognised.

A retroperitoneal haematoma may be associated with femoral artery puncture with or without the use of a closure device after the intervention (41) (Fig 2). It is caused by inadvertent puncture of the posterior wall of the femoral or iliac artery during cannulation. Bleeding may be exacerbated by the fact that most coronary patients are likely to receive antiplatelet therapy in the form of aspirin, clopidogrel or dipyridamole (42), and are being anticoagulated with heparin (unfractionated or low molecular weight) (43–45). Activated clotting time (ACT) is not accurate in predict bleeding complications in these patients (46).

In a retrospective review of 9585 femoral artery catheterisations in a single centre, Kent et al. (47) showed that the overall prevalence of retroperitoneal haematoma was 0.5% (45 patients). In this cohort of patients, the highest frequency of this complication developed after coronary artery stenting (3%), when the sheaths were of large calibre. In the group of patients who underwent coronary artery stenting, other statistically significant predictors of included female sex (presumably because of smaller artery size and therefore more prone to puncture), low platelet count and excessive anticoagulation (47). Waksman et al. showed in a series of 5042 patients who underwent percutaneous transluminal coronary angioplasty that 6% had retroperitoneal bleeding (48). In this series, vascular complications were associated with age, female gender, increased weight, higher systolic blood pressure, increased per- and postprocedure heparin dose and coronary stenting (rather than angioplasty alone) (48). In a study of 688 consecutive patients treated with directional coronary atherectomy or Palmaz-Schatz coronary stenting, Moscucci et al. found that additional independent predictors of this vascular complication included age of more than 70 years, multiple procedures and hypertension (49). Lumsden et al. (50) found in a series of 100 cardiac patients that the incidence of retroperitoneal haematomas was 5.1%. In 26 patients with retroperitoneal haematoma of 3508 consecutive patients undergoing percutaneous coronary intervention, Farouque et al. found that female gender, low body surface area and higher femoral artery puncture were independent predictors of retroperitoneal haematoma. In this study, there was no association between retroperitoneal haematoma and the size of the arterial sheath, use of glycoprotein IIb/IIIa inhibitors or deployment of a vascular closure device (51,52). In a series of 10,440 consecutive patients undergoing coronary intervention, Nicolai et al. found that nearly a fifth of the patients had symptomatic peripheral arterial insufficiency; and these patients had higher rates of retroperitoneal haematoma after coronary intervention compared with those without peripheral arterial disease (53).

Although multiple attempts or high puncture points above the inguinal ligament of the femoral artery may provide some clue as to ongoing occult retroperitoneal bleeding, this is not always the case. Analysing 44 patients who developed retroperitoneal haematoma after femoral vessel puncture, Quint et al. (54) showed that the site of the haematoma did not correlate well with the femoral puncture site on CT. If the haematoma is not contiguous with the punctured femoral vessels, coagulopathy was most likely to be the cause of the haemorrhage. However, this study did not take into account multiple punctures of the femoral artery. Occasionally, the retroperitoneal bleed may be unrelated to the vessel being punctured and may occur after inadvertent laceration of an arterial branch (55).

Most of these patients who had iatrogenic injury of the femoral or iliac vessels have significant co-morbidity, such as acute coronary syndrome or unstable angina. They are often at high anaesthetic risk. They are often anticoagulated or on clopidogrel, making regional epidural anaesthesia unsafe.
Endovascular treatment is, therefore, preferable to open surgery.

**Clinical presentation**

The presentation is varied and may be vague, and diagnosis is often delayed if the clinician is unaware of this condition. Patients who have uncontrolled bleeding in the retroperitoneum initially exhibit very subtle clinical signs of haemorrhage. They often do not have any obvious stigmata of underlying expanding haematoma or cutaneous bruising. Relative hypotension and mild tachycardia that transiently improves with administration of fluids should alert the astute clinician to the diagnosis of retroperitoneal haematoma and necessitate further investigation (56). Some patients may be unable to mount tachycardia because of beta-blockers, and these patients usually become hypotensive with no change in their heart rate.

---

Figure 2 Iatrogenic injury by femoral arterial line with large right-sided retroperitoneal haematoma. Active bleeding is seen on CT (white arrow) with separation of contrast (A). Emergency arteriogram shows active bleeding from lumbar arteries (white arrows) (B). This was successfully embolised with coils (black arrow) (C). Patient required laparostomy because of intra-abdominal compartment syndrome. CT scan, 3 months later, showed complete resolution of the haematoma with satisfactory abdominal wall healing after prolonged vacuum-assisted closure (VAC) device (D)
Patients may present with back, lower abdominal or groin discomfort and swelling, which may progress to haemodynamic instability, collapse and a fall in haemoglobin, depending on the severity of the haemorrhage. There may be other precipitating events (such as trauma) or significant past medical history (renal failure, anticoagulation therapy or dialysis).

In a retrospective review of 26 patients who underwent coronary angiography and developed retroperitoneal haematoma, Farouque et al. (51) showed that 42% of patients presented with abdominal pain, 46% with groin discomfort and 23% with back pain. In this series, 58% of patient developed sweating, 31% became bradycardic, with the majority of patients (92%) developing hypotension with a mean systolic blood pressure of 75 mmHg.

Sasson et al. showed in a review of 51 patients with spontaneous retroperitoneal haematoma that haematoma near or within the iliopsoas muscle usually presents as femoral neuropathy, which usually begins with groin pain or leg weakness, and that early identification is crucial to improving patient morbidity and mortality (22). Femoral neuropathy caused by retroperitoneal haematoma presents with sudden onset severe pain in the affected groin and hip, with radiation to the anterior thigh and the lumbar region. Iliopsoas muscle spasm often results in the characteristic flexion and external rotation of the hip, and any attempt to extend the hip will result in severe pain. Later on, pain and parasthesia in the antero-medial thigh and leg is characteristic (57). The reason for this can be explained by anatomic studies which revealed that the fascia overlying the iliopsoas muscle and the femoral nerve is strong and not easily stretched in the presence of underlying haematoma formation (58). As a result, femoral nerve compression occurs along the iliopsoas gutter, where it is also at most risk for ischaemia because of the poor vascular supply to this region of the nerve (59). In addition, the haematoma may track down the iliopsoas muscle into femoral canal, compressing the femoral nerve against the rigid inguinal ligament, resulting in further ischaemia and resultant neuropathy (57).

**Diagnostic imaging**

In the case of trauma, plain abdominal and pelvic radiographs may be able to demonstrate loss of the psoas shadow or an unstable pelvic ring fracture, but such tests are rarely sensitive or specific enough for the diagnosis of retroperitoneal bleed. Ultrasonography of the abdomen and pelvis may detect haematoma, but this is not precise enough to ascertain the cause. Ultrasound is often limited by patient’s discomfort, body habitus, underlying bowel gas and operator skill (60,61). Free fluid or blood in the retroperitoneum often pass into the abdominal or pelvic cavity, and can be detected as free abdominal fluid on ultrasound scan (62). In a series of 37 patients with retroperitoneal fluid (not all of whom had retroperitoneal haemorrhage), 16% of patients had peritoneal extension. The most common pathway is from the infrarenal extraperitoneal space into the pelvic extraperitoneal space dorsally medial to the iliac vessels, although fluid can also extend lateral to the iliac vessels or medially into the prevesical space (63).

Multi-detector-row CT plays an important role in the diagnosis of retroperitoneal haematoma, providing useful information on the type, site and extent of the fluid collections. CT scan is noninvasive, rapidly obtainable and highly sensitive. Even in an unenhanced CT scan, the haematoma appears as an abnormal soft tissue density which compresses adjacent normal structures (64). An accurate CT assessment requires the awareness of the existence of dissectable retroperitoneal fascial planes, and knowledge of the appearance and location of the normal fascial structures is the key to proper CT interpretation of retroperitoneal haematoma collection (65).

Spiral CT allows higher image quality by multi-planar reconstructions and maximum intensity projection images, reducing artefacts caused by respiration, and obtained from datasets with high spatial resolution. Active bleeding can be seen as extravasation of contrast material, seen as a jet and ‘layering on the hematocrit level’ within the haematoma (66). CT angiography may show the site of the bleed and contrast outside the vessels required urgent treatment.

Magnetic resonance imaging (MRI) is very sensitive for the detection of retroperitoneal structures, although it is mainly used in the imaging of tumours, because collagen fibres, calcification and fat have characteristic MR imaging features (67). It is useful in patients presenting with femoral neuropathy as a consequence of retroperitoneal bleed, as MRI helps to rule out nerve root compression or spinal problems (57). However, it is expensive, and many cardiac patients are unable to have this study as they often have contraindications, such as pacemaker, and recently deployed coronary stents which may interact with the magnetic field. It is not commonly used in the diagnosis of retroperitoneal haematoma. MR angiography may also show the site of the bleed together with any extra-vascular leak of contrast.

In patients who are haemodynamically unstable, urgent digital subtraction angiography with a view to selective embolisation or placement of a stent graft is
indicated. The transfemoral route from the contralateral artery is usually used for access.

**Conservative management in retroperitoneal haemorrhage**

The treatment of retroperitoneal haematoma remains controversial. Whatever the aetiology of the retroperitoneal bleed, all patients should initially be managed in a high dependency unit or intensive care unit with careful monitoring, fluid resuscitation, blood transfusion and normalisation of coagulation factors. In the presence of coagulopathy, inherited clotting disorders, such as congenital haemophilia and acquired (autoimmune) haemophilia, it is generally accepted that clotting factor replacement and a conservative non-intervention approach may suffice (68–70). If the patient is anticoagulated with warfarin at the time of the diagnosis, the best treatment option would be infusion of a prothrombin complex concentrate, such as octaplex or beriplex, which contain all the deficient factors (II, VII, IX and X) encountered in warfaranised patients (71,72). In patients with haemophilia, the use of sequential therapy with activated prothrombin complex and recombinant-activated factor VII (NovoSeven, Novo Nordisk UK, Crawley, West Sussex, UK) had shown encouraging results (73). There are also reports to suggest that early diagnosis of retroperitoneal haematoma following relatively minor trauma respond well to conservative management (74,75). Surgery to remove the haematoma may reduce the effect of tamponade and could potentially make matters worse.

There are no specific guidelines to suggest when to intervene with endovascular or open surgery to stop the bleeding. If the patient is haemodynamically stable with no evidence of on-going bleeding, conservative management is recommended. In the case of spontaneous retroperitoneal haemorrhage, the mainstay of management remains conservative, with withdrawal of anticoagulation therapy, correction of coagulopathy, volume resuscitation and supportive measures (22). The initial view that spontaneous retroperitoneal haemorrhage is an angiographically occult diffuse microvascular condition, in which angiography had no diagnostic or therapeutic role has been challenged by several case reports (76). There are isolated case reports in the literature on the use of activated factor VII especially in trauma (77,78).

**Endovascular treatment in retroperitoneal haemorrhage**

There is a growing trend in the use of endovascular techniques as an alternative to open surgery in the management of retroperitoneal haemorrhage. The main options are selective intra-arterial embolisation or stent-grafts to stop the bleeding. Intra-arterial embolisation is being used with increasing frequency in cases where the angiogram shows active bleeding sites (79). In this series by Isokangas et al., four patients were operated on prior to embolisation, but surgery failed to control the bleeding. Embolisation using a combination of agents, such as coils, gelatin and/or polyvinyl alcohol, has been used. Coils are probably the safest, but Isokangas et al. commented that proximal coiling of the bleeding artery may not be sufficient in the retroperitoneum, where there is a rich network of collateral arteries and new arterial pathways may develop after obliteration of the lumbar arteries (80,81). It is important to place embolic agents both proximally and distally to the bleeding site to prevent re-bleeding. Although bleeding was stopped or markedly decreased after embolisation in eight patients, five patients developed abdominal compartment syndrome requiring surgical or radiological decompression procedures (79).

The indications for embolisation are based on the haemodynamic stability of the patient and the degree of blood loss. Panetta et al. (82) stated that haemodynamic instability despite four or more units of blood transfusion within 24 h, or six or more units of blood transfusion within 48 h is an indication for urgent investigation and endovascular treatment. Embolisation should be performed whenever arterial extravasation is seen. Some authors argue that angiography should not be performed unless the interventional radiologist is prepared to embolise when signs of arterial injury are identified (83).

Sharafuddin et al. (76) showed that selective arterial embolisation was successful in a series of five patients, although rebleeding occurred in one patient. Subsequent small case series have shown similar results. Pathi et al. (84) showed in a series of four patients that embolisation was successful in all patients, and the bleeding was multi-focal in one patient. In a single hospital’s experience, Isokangas et al. showed that in 10 consecutive patients with retroperitoneal haemorrhage secondary to anticoagulant treatment, nine were treated technically successfully with endovascular embolisation, with clinical success in eight patients (79).

Embolisation is becoming more common as an alternative to open surgery in the treatment of retroperitoneal bleed following iatrogenic injuries, after procedures such as percutaneous lumbar sympathectomy, renal biopsy (85), percutaneous nephrostomy (86,87) or following iatrogenic iliofemoral vessel injuries (41,55).
There are very few heterogeneous case series or reports on stent-grafts in the management of retroperitoneal haematoma. Watarida et al. (88) reported successful use of a fenestrated stent-graft to manage a traumatic rupture of the juxtahepatic inferior vena cava. In these cases, proper facilities, radiological expertise and experienced, and an assortment of devices must be available. Traumatic aortic rupture with retroperitoneal haematoma can also be treated with a combined operative and endovascular approach (89). Posterior iatrogenic injury to the iliac artery can also be treated with a stent-graft, provided the position is not over the hip joint (90).

**Open surgery in retroperitoneal haemorrhage**

There was once a view that all retroperitoneal haemorrhage should be treated conservatively, as it was believed that open surgery may disturb the tamponade effects of the retroperitoneum. Open surgery is indicated if the patient remains unstable despite adequate fluid and blood product resuscitation, or if interventional radiology is not successful or unavailable. These patients are inevitably critically ill. It is important for the coagulopathy to be totally corrected prior to surgery. The primary aim for surgery is to control all actively bleeding points, and the secondary aim is to remove the large haematoma. The retroperitoneum may need to be packed and re-explored at 24–48 h (91).

Another indication for open surgery is when the patient develops abdominal compartment syndrome as a result of the large retroperitoneal haematoma (14,92). In selective cases, image-guided drainage of haematoma may be an alternative to open surgery to release intra-abdominal pressure (79). If untreated, patients may develop signs of increased intra-abdominal pressure with impaired respiratory, cardiovascular and renal function. Once these complications have developed, urgent decompression of the abdomen by means of a laparostomy with the use of a Bogota bag (and leaving the retroperitoneal intact) is indicated. Sometimes this is not possible, as the haematoma is so tense that it will erupt anteriorly once the abdominal pressure is released. In such cases, the retroperitoneal haematoma can be evacuated. If there is persistent bleeding despite meticulous haemostasis, the retroperitoneum can be packed. Measurement of intra-abdominal pressure can be easily performed via a urinary catheter (93).

Surgery is often guided by preoperative CT findings. In cases when such preop imaging is unavailable or impossible, the surgeon has several distinctive patterns of retroperitoneal haematoma to guide him to specific vascular injury. Detailed discussion of this is beyond the scope of this review article, suffice it to say that an upper abdominal midline supra-mesocolic retroperitoneal haematoma is associated with bleeding from the supra-renal aorta, coeliac axis or the superior mesenteric artery (94,95). The mid-abdominal midline infra-mesocolic retroperitoneal haematoma is associated with proximal renal artery, infra-renal aorta or caval injury (96). A peri-nephric haematoma is associated with renal artery rupture. A midline haematoma is mostly associated with pelvic fracture, bladder injury or iliac vessel injury. A right lateral retroperitoneal haematoma suggests a high infra-renal or retro-hepatic caval injury, which is associated with hepatic injury and a high mortality (97). All the blood should be removed and the abdomen packed with large swabs. These can then be removed in turn to identify the source of the bleeding.

**Conclusion**

Retroperitoneal haemorrhage is a rare clinical entity which requires a high index of clinical suspicion. If treated inappropriately, retroperitoneal bleeding is associated with high morbidity and mortality. It should be suspected in elderly patients by anticoagulants or renal dialysis and those patients who have had an invasive procedure via the femoral artery or vein. Correction of underlying coagulopathy and resuscitation with fluids and blood products is essential. Urgent high quality CT imaging is mandatory to document the type, site and extent of the haematoma.

Most patients with spontaneous or iatrogenic retroperitoneal haematoma can be monitored closely and treated conservatively without further intervention. Emergency angiography with a view to embolise or stent-graft the bleeding vessel(s) is indicated if the CT examination shows active extravasation of contrast. Surgery can have its place in very selective cases, but removal of the haematoma may increase bleeding by removing the tamponade effect, and packing with large abdominal gauze may be the only surgical option, if no specific arterial bleed but general ooze can be identified per-operatively. Abdominal compartment syndrome may require decompression laparostomy.

Ideally a randomised controlled trial of open surgery vs. endovascular treatment of retroperitoneal haematoma should be performed but this will be impossible to perform because of the low incidence, and emergency presentation of retroperitoneal haemorrhage.
Management of retroperitoneal haemorrhage

References

1 Ritter U. Extensive retroperitoneal hematoma following diagnostic anesthesia of the lumbar sympathetic nerve. *Chirurg* 1950; 21: 434–5.

2 Scheiber L, Szombathelyi J, Botar G. Retroperitoneal hematoma following acute pancreatitis. *Orv Hetil* 1951; 92: 1667–9.

3 Estivill Palleja X, Domingo P, Fontcuberta J, Felix J. Spontaneous retroperitoneal hemorrhage during oral anticoagulant therapy. *Arch Intern Med* 1985; 145: 1531–4.

4 Prabules AM, Chen HH, Rodis JP et al. Angiographic embolization of a ruptured renal artery aneurysm during pregnancy. *Obstet Gynecol* 1997; 90: 663–5.

5 Bonamigo TP, Erling N Jr, Faccini FP. Rupture of a saccular renal artery aneurysm: report of a case. *Surg Today* 2002; 32: 753–5.

6 Capollone G, Santarelli G, Mucilli F et al. Hemoperitoneum secondary to aneurysm of the pancreatic-duodenal artery: report of a clinical case. *Ann Ital Chir* 2001; 72: 347–50.

7 Fujisawa T, Sakaguchi K, Onishi Y et al. Ruptured aneurysm of pancreaticoduodenal artery, report of two cases. *Nippon Shokakibyo Gakkai Zasshi* 2005; 102: 1146–52.

8 Buresta P, Freyrie A, Paragona O, D’Addato M. Ruptured pancreatoduodenal artery aneurysm. A case report and review of the literature. *J Cardiovasc Surg (Torino)* 2004; 45: 153–7.

9 Manabe Y, Yoshikoa K, Yanada J. Spontaneous rupture of a dissection of the left ovarian artery. *J Med Invest* 2002; 49: 182–5.

10 Bigeacu S, Cuilleron M, Kaczmarek D, Porcheron J. True aneurysms of the pancreato-duodenal artery: successful non-operative management. *Surgery* 2006; 139: 608–16.

11 Tappe U, Kristen F, Loffler A, Keller HW. Spontaneous retroperitoneal hematoma in adrenal metastasis. *Dtsch Med Wochenschr* 1997; 122: 471–4.

12 Demey A, de la Taille A, Vordos D et al. Complications of retroperitoneal laparoscopy based on a series of 500 cases. *Prog Urol* 2006; 16: 128–33.

13 Lim WC, Leblanc JK. Retroperitoneal bleeding after EUS-guided FNA of a pancreatic mass. *Gastrointest Endosc* 2006; 63: 499–500.

14 Dabney A, Bastani B. Exonaparin-associated severe retroperitoneal bleeding and abdominal compartment syndrome: a report of two cases. *Intensive Care Med* 2001; 27: 1954–7.

15 Pode D, Caine M. Spontaneous retroperitoneal hemorrhage. *J Urol* 1992; 147: 311–8.

16 Lerer DB, Rozenblit AM, Cynamon J et al. Spontaneous retroperitoneal hemorrhage localized by blood pool scintigraphy. *Clin Nucl Med* 2004; 29: 96–8.

17 Figer TT, Keshavarzian A, Nand S, Demos TC. Retroperitoneal amyloidosis, factor IX and X deficiency, and gastrointestinal bleeding. *Abdom Imaging* 1996; 21: 266–8.

18 Eby CS, Caracioni AA, Badar S, Joist JH. Massive retroperitoneal pseudotumour in a patient with type 3 von Willebrand disease. *Haemophilia* 2002; 8: 136–41.

19 Lai S, Walker DH, Elghetaty MT. Catastrophic antiphospholipid syndrome: a rare cause of disseminated microvascular thrombotic injury – a case report with pathological and molecular correlative studies. *Pathol Int* 2005; 55: 144–9.

20 Jurics D, Doko M, Glavan E et al. Spontaneous retroperitoneal haematoma associated with clopidogrel therapy mimicking acute appendicitis. *Br J Clin Pharmacol* 2006; 62: 248–9.

21 Bhasin HK, Dana CL. Spontaneous retroperitoneal hemorrhage in chronically hemodialyzed patients. *Nephron* 1978; 22: 322–7.

22 Mant MJ, O’Brien BD, Thong KL et al. Haemorrhagic complications of heparin therapy. *Lancet* 1977; I: 1133–5.

23 Forfar JC. A 7-year analysis of haemorrhage in patients on long-term anticoagulant treatment. *Br Heart J* 1979; 42: 128–32.

24 Emnts M, Mohan PS, Fares LG II, Hardy H III. A retroperitoneal bleed induced by enoxaparin therapy. *Am Surg* 2005; 71: 430–3.

25 Kalinowski EA, Terletota SO. Postcatheterization retroperitoneal hematoma due to spontaneous lumbar arterial hemorrhage. *Cardiovasc Intervent Radiol* 1998; 21: 337–9.

26 Sasson Z, Mangat I, Peckham KA. Spontaneous iliopectas hematoma in patients with unstable coronary syndromes receiving intravenous heparin in therapeutic doses. *Can J Cardiol* 1996; 12: 490–4.

27 Khan FY, Hassan IF, Allity MH, Khan SM. Retroperitoneal hematoma following reboobx and enoxaparin coadministration in a patient with atrial fibrillation. *Saudi Med J* 2005; 26: 336–7.

28 Kravitz MS, Mishal RA, Shoenfeld Y. Renal failure and low molecular weight heparins. A dangerous liaison? The case of retroperitoneal hematoma. *Ir Med Assoc J* 2005; 7: 600–1.

29 Lopez-Sanchez M, Gonzalez-Fernandez C, Valero-Diaz de Madrid C et al. Enoxaparin, retroperitoneal haematoma in the elderly and impaired renal function. *Anaeth Intensive Care* 2005; 33: 890–9.

30 Kruzel-Davila E, Frajewicki V, Kushnir D et al. Retroperitoneal hematoma in a hemodialysis patient receiving low molecular weight heparin. *Ir Med Assoc J* 2003; 7: 611–2.

31 Torres GM, Cerniglio JG, Abbit PT et al. Iliopsoas compartment: normal anatomy and pathologic processes. *Radiographics* 1995; 15: 1285–97.

32 Qanadli SD, EI Hajjam M, Mignon F et al. Life-threatening spontaneous psoas haematoma treated by transcatheter arterial embolization. *Eur Radiol* 1999; 9: 1231–4.

33 McCott J. Intraperitoneal and retroperitoneal hemorrhage. *Radiol Clin North Am* 1976; 14: 391–405.

34 Bena JD, Zauzur I, Madrigal M et al. Conservative treatment of large rectus sheath hematoma in patients undergoing anticoagulant therapy. *Abdom Imaging* 2006; 28: 230–4.

35 Aronstam A, McLellan DS, Turk P. Transfusion requirements of adolescents with severe haemophilia A. *J Clin Pathol* 1979; 32: 927–30.

36 Arbini AA, Mannucci PM, Bauer KA. Low prevalence of the factor V Leiden mutation among ‘severe’ hemophiliaics with a milder bleeding diathesis. *Thromb Haemost* 1995; 74: 1255–8.

37 Yilmaz S, Oren H, Irken G et al. Life-threatening mediastinal-retroperitoneal hemorrhage in a child with moderate hemophilia A and high inhibitor titer: successful management with recombinant activated factor VII. *J Pediatr Hematol Oncol* 2005; 27: 400–2.

38 Marquand J, Neveux JY, Guivarch M. Apropos of a case of dissecting haematoma of the abdominal aorta with retroperitoneal and digestive rupture, a complication of lumbar aortography. *Mem Acad Chir (Paris)* 1963; 89: 804–12.

39 Selinding SI. Catheter replacement of the needle in percutaneous arteriography: a new technique. *Radiology* 1953; 89: 368–76.

40 Sreeram S, Lumsden AB, Miller JS et al. Retroperitoneal hematoma following femoral arterial catheterization: a serious and often fatal complication. *Am Surg* 1993; 59: 94–8.

41 Lubavin BV. Retroperitoneal hematoma as a complication of coronary angiography and stenting. *Am J Emerg Med* 2004; 22: 236–8.

42 Dorros G, Bates MC, Iyer S et al. Gianturco-Roubin flexible metallic coronary stents in old saphenous vein grafts: in-hospital outcome and 7 day angiographic patency. *Eur Heart J* 1994; 15: 1456–62.

43 Power GE, Rogers P. Retroperitoneal haemostoma associated with low molecular weight heparin. *Anaesth Intensive Care* 2002; 30: 665–7.

44 Aydin M, Ozeren A, Bilge M et al. Retroperitoneal hematoma following tirofiban and enoxaparin coadministration in a patient with acute coronary syndrome. *Thromb Res* 2003; 111: 121–3.

45 Levine GN, Kern MJ, Berger PB et al., American Heart Association Diagnostic and Interventional Catheterization Committee and Council on Clinical Cardiology. Management of patients undergoing percutaneous coronary revascularization. *Ann Intern Med* 2003; 139: 123–36.

46 Breuer SJ, Blutt DL, Moliterno DJ et al. Revisiting optimal anticoagulation with unfractionated heparin during coronary stent implantation. *Am J Cardiol* 2003; 92: 1468–71. 
47 Kent KC, Moscucci M, Mansour KA et al. Retroperitoneal hema-
oma after cardiac catheterization: prevalence, risk factors, and
optimal management. J Vasc Surg 1994; 20: 905–13.
48 Waksman R, King SB III, Douglas JS et al. Predictors of groin
complications after balloon and new-device coronary intervention.
Am J Cardiol 1995; 75: 886–9.
49 Moscucci M, Mansour KA, Kent KC et al. Peripheral vascular
complications of directional coronary atherectomy and stenting:
predictors, management, and outcome. Am J Cardiol 1994; 74:
448–53.
50 Luimden AB, Miller JM, Kosinski AS et al. A prospective evalu-
aton of surgically treated groin complications following percutane-
ous cardiac procedures. Am Surg 1994; 60: 132–7.
51 Farouque HM, Tremmel JA, Raissi Shahari F et al. Risk factors
for the development of retroperitoneal hematoma after percuta-
neous coronary intervention in the era of glycoprotein IIb/IIIa
inhibitors and vascular closure devices. J Am Coll Cardiol 2005;
45: 363–8.
52 Gonze MD, Sternbergh WC III, Salartash K, Money SR. Complica-
tions associated with percutaneous closure devices. Am J Surg
1999; 178: 209–11.
53 Nikolosky E, Mehran R, Mintz GS et al. Impact of symptomatic
peripheral arterial disease on 1-year mortality in patients under-
going percutaneous coronary interventions. J Endovasc Ther 2004;
11: 60–70.
54 Quint LE, Holland D, Korobkin M, Cascade PN. Role of femoral
vessel catheterization and altered hemostasis in the development of
extraperitoneal hematoma: CT study in 44 patients. AJR Am J
Roentgenol 1993; 160: 855–8.
55 Alomari AL. Retroperitoneal bleeding after inadvertent laceration
of an arterial collateral during central venous catheterization; treat-
ment with embolization. Emerg Radiol 2006; 12: 278–81.
56 Money SR, Lepore MR. Iatrogenic vascular trauma. In: Rich NM,
Jorde HE, editors. Radiographics 2004; 24: 554–5.
57 Parmer SS, Carpenter JP, Fairman RM et al. Femoral neuropathy
following retroperitoneal hemorrhage: case series and review of the
literature. Am Surg 2006; 70: 536–40.
58 Nobed W, Mark SC, Kubik S. The anatomical basis for femoral
nerve palsy following iliacus hematoma. J Neurosurg 1980; 52:
533–40.
59 Goodfellow J, Fearn CB, Matthews JM. Iliacus haematoma. A com-
mon complication of haemophilia. J Bone Joint Surg Br 1967;
49: 748–56.
60 Silverstein A. Neuropathy in hemophilia. JAMA 1964; 190: 554–
5.
61 Merrick HW, Zeiss J, Woldenberg LS. Percutaneous decompression
for femoral neuropathy secondary to heparin-induced retroperito-
neal hematoma: case report and review of the literature. Am Surg
1991; 57: 706–11.
62 Ruchholtz S, Waydhas C, Lewan U et al. Free abdominal fluid on
ultrasound in unstable pelvic ring fracture: is laparotomy always
necessary? J Trauma 2004; 57: 278–87.
63 Akhavan H, Tanoue S, Okino Y et al. Pelvic extension of retroperito-
neal fluid: analysis in vivo. AJR Am J Roentgenol 1998; 171: 671–7.
64 Lindner A, Zierer S. Images in clinical medicine. Retropertioneal
hemorrhage. N Engl J Med 2001; 344: 348.
65 Scalpi M, Scaglione M, Angiulli G et al. Emergencies in the retro-
peritoneum: assessment of spread of disease by helical CT. Eur J
Radiol 2004; 50: 74–83.
66 Becker CD, Mentha G, Schmidlin F, Terrier F. Blunt abdominal
trauma in adults: role of CT in the diagnosis and management of
visceral injuries. Part 2: Gastrointestinal tract and retroperitoneal
organs. Eur Radiol 1998; 8: 772–80.
67 Nishimura H, Zhang Y, Ohkuma K et al. MR imaging of soft-tis-
sue masses of the extraperitoneal spaces. Radiographics 2001;
21: 1141–54.
68 Ylmaz S, Oren H, Iken G et al. Life-threatening mediastinal-retro-
peritoneal hemorrhage in a child with moderate hemophilia A and
high inhibitor titer: successful management with recombinant activ-
ated factor VII. J Pediatr Hematol Oncol 2005; 27: 400–2.
69 Kondo E, Utsumi M, Hattori M et al. Acquired factor VIII-specific
antibody disorder accompanied by a life-threatening retroperito-
neal hematoma. Intern Med 1995; 34: 901–3.
70 Lenzkuller K, Bach F, Kobert K et al. Acquired hemophilia A as a
cause of postoperative bleeding. Anasthesiol Intensivmed Notfallmed
Schmerzther 2003; 38: 559–65.
71 Riess HB, Meier-Hellmann A, Motsch J et al. Prothrombin com-
plex concentrate (Octaplex(R))) in patients requiring immediate
reversal of oral anticoagulation. Thromb Res 2007 (in press).
72 Preston FE, Laidlaw ST, Sampson B et al. Rapid reversal of oral
anticoagulation with warfarin by a prothrombin complex concen-
trate (Beriplex): efficacy and safety in 42 patients. Br J Haematol
2002; 116: 619–24.
73 Schneiderman J, Rubin E, Nugent DJ et al. Sequential therapy with
activated prothrombin complex concentrates and recombinant
FXIII in patients with severe haemophilia and inhibitors: update of
our previous experience. Haemophilia 2007; 13: 244–8.
74 Reinstein L, Alevizatos AC, Twardzik FG, DeMarco SJ III. Femoral
erve dysfunction after retroperitoneal hemorrhage: pathophysiolo-
gy revealed by computed tomography. Arch Phys Med Rehabil
1984; 65: 37–40.
75 Fealy S, Paletta GA Jr. Femoral nerve palsy secondary to traumatic
iliacus muscle hematoma: course after nonoperative management.
J Trauma 1999; 47: 1150–2.
76 Sharafuddin MJ, Abraham JI, Sun S et al. Spontaneous extraperi-
toneal hemorrhage with hemodynamic collapse in patients under-
going anticoagulation: management with selective arterial
embolization. J Vasc Interv Radiol 2001; 12: 1231–4.
77 McPherson J, Teague L, Lloyd J et al. Experience with recombinant
factor VIIIa in Australia and New Zealand. Haemostasis 1996; 26
(Suppl. 1): 109–17.
78 Williams DJ, Thomas GO, Pambakian S, Parker PJ. First military
use of activated Factor VII in an APC-III pelvic fracture. Injury
2005; 36: 395–9.
79 Iokan JM, Peral JM. Endovascular embolization of sponta-
neous retroperitoneal hemorrhage secondary to anticoagulant
embolization. Cardiovasc Intervent Radiol 2004; 27: 607–11.
80 Kauppila LI. Blood supply of the lower thoracic and lumbosacral
regions. Postmortem aortography in 38 young adults. Acta Radiol
1994; 35: 541–4.
81 Kauppila LI. Prevalence of stenotic changes in arteries supplying
the lumbar spine. A postmortem angiographic study on 140 sub-
jects. Ann Rheum Dis 1997; 56: 591–5.
82 Panetta T, Schafani SJ, Goldstein AS et al. Percutaneous transcathe-
erterial embolization for massive bleeding from pelvic fractures.
J Trauma 1985; 25: 1021–9.
83 Schafani SJ, Florence LO, Phillips TF et al. Lumbar arterial injury:
radiologic diagnosis and management. Radiology 1987; 165: 709–
14.
84 Pathi R, Voyvodic F, Thompson WR. Spontaneous extraperitoneal
haemorrhage: computed tomography diagnosis and treatment by
selective arterial embolization. Australas Radiol 2004; 48: 123–8.
85 Yanik V, Martinez V, Padre R et al. Embolization of lumbar artery
due to retroperitoneal bleeding following renal biopsy. Nephrol Dial
Transplant 2005; 20: 820–2.
86 Wilms G, Baert AL. Embolization of iatrogenic pelvic and retro-
peritoneal hemorrhage. J Belge Radiol 1989; 72: 279–82.
87 Calam P, Nonent M, Fourrier G et al. Endovascular treatment of
traumatic and iatrogenic intrarenal arterial lesions by microcoil
embolization. Ann Radiol (Paris) 1996; 39: 234–9.
88 Watarida S, Nishi T, Furukawa A et al. Fenestrated stent-graft for
traumatic juxtarenal inferior vena cava injury. J Endovasc Ther
2002; 9: 134–7.
89 Lindblad B, Brunowall J, Lindh M et al. Traumatic aortic rupture
and retroperitoneal haematoma – treatment including combined
operative and endovascular approach. Eur J Vasc Endovasc Surg
1999; 17: 451–5.
90 Park SI, Won JH, Kim BM, Kim JK, Lee DY. The arterial folding point during flexion of the hip joint. *Cardiovasc Intervent Radiol* 2005; 28: 173–7.

91 Finlay IG, Edwards TJ, Lambert AW. Damage control laparotomy. *Br J Surg* 2004; 91: 83–5.

92 Howdieshell TR, Proctor CD, Sternberg E et al. Temporary abdominal closure followed by definitive abdominal wall reconstruction of the open abdomen. *Am J Surg* 2004; 188: 301–6.

93 Loftus IM, Thompson MM. The abdominal compartment syndrome following aortic surgery. *Eur J Vasc Endovasc Surg* 2003; 25: 97–109.

94 Accola KD, Feliciano DV, Mattos KL et al. Management of injuries to the superior mesenteric artery. *J Trauma* 1986; 26: 313–9.

95 Mattos KL, Burch JM, Richardson R, Martin RR. Retroperitoneal vascular injury. *Surg Clin North Am* 1990; 70: 635–53.

96 Leppaniemi AK, Savolainen HO, Salo JA. Traumatic inferior vena caval injuries. *Scand J Thorac Cardiovasc Surg* 1994; 28: 103–8.

97 Klein SR, Baumgartner FL, Bongard FS. Contemporary management strategy for major inferior vena caval injuries. *J Trauma* 1994; 37: 35–42.

*Paper received March 2007, accepted June 2007*