

Endovascular Treatment of a Perforated Femoral Artery

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ABSTRACT: We describe here an endovascular approach to a perforation in the right femoral artery that was emergently closed with gel foam as the patient's blood pressure fell rapidly to 40 mm Hg systolic. There have been previous reports of closing the deep circumflex iliac artery with coils and balloon occlusion, but here we sealed a perforation in the femoral artery with gel foam. Unfortunately, the rent was caused while reintroducing an arterial sheath due to a mistake by the operator.

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Key words: iatrogenic rent in the femoral artery, closure by embolization, gel foam

Iatrogenic injury to the femoral vessels can occur inadvertently. At times, this leads to a pseudoaneurysm or an arteriovenous fistula.¹ However, at times this can lead to shock, exsanguination, and a large retroperitoneal hematoma. To date, femoral procedures have been blamed for the increased mortality during angioplasty, especially when compared to radial route procedures.

We describe here a patient whose femoral artery was damaged during (at the end of) angioplasty and how we have prevented a death by endovascular means.

CASE REPORT

Our patient was a 62-year-old male who presented to the hospital with non-ST elevation myocardial infarction (NSTEMI). He was a non-smoker with no history of diabetes mellitus or systemic hypertension. On examination his heart rate was 80 bpm, and his blood pressure was 110/70. He had no cardiomegaly. He had a median sternotomy scar down the middle of his chest. His heart sounds were normal and he had no murmurs. Electrocardiogram showed a rate of 80 bpm, sinus rhythm. Mean frontal QRS axis was +60°, PR interval was 160 ms, and QRS duration was 80 ms; he had ST-T changes in the inferolateral leads.

Echocardiogram: The left ventricular internal dimension was 6.3 cm in diastole and 4.9 cm in systole. Interventricular septal thickness was 0.7 cm in diastole and 0.8 cm in systole. Posterior wall thickness was 0.9 cm in diastole and 1 cm in systole. His ejection fraction was 50%. The patient had regional wall motion abnormality of the left anterior descending (LAD) coronary artery territory more than the left circumflex (LCX) territory. He had mild mitral regurgitation (MR) and mild tricuspid regurgitation (TR), with mildly dilated left ventricle and stage 1 diastolic dysfunction.

Other investigations revealed initial hemoglobin of 11.7 g/dL, total leukocyte count of 8500/mm³, ESR of 12 mm/hr, serum sodium of 133 mEq/L, serum potassium of 3.7 mEq/L, blood urea

of 20 mg/dL, serum creatinine of 0.8 mg/dL, and platelet count of 250,000/mm³.

Coronary angiogram revealed a 50% stenosis in the left main coronary artery (LMCA). The LAD had an ostio-proximal tubular lesion of 60% tapering to a total occlusion. The distal LAD filled from homo-collaterals. The distal right coronary artery (RCA) was seen filling by hetero-collaterals. The mid RCA was totally occluded distally and the LCX was non-dominant, a 2.75 cm vessel that was diffusely diseased.

Graft study: The graft to the right posterior descending artery (RPDA) was cannulated and had a discrete eccentric lesion of 90% at the proximal anastomotic site and another lesion of 80% at the distal anastomotic site. The LAD, diagonal, and obtuse marginal (OM) grafts could not be visualized.

There was a final diagnosis of LMCA + triple-vessel disease, distal RCA disease, and diffuse disease of the LCX. The LAD had a proximal chronic total occlusion (CTO).

Since the coronary artery bypass graft (CABG) surgery had been done 1 year earlier, it was decided that we would perform a native vessel angioplasty.

After preloading with clopidogrel 300 mg and aspirin 325 mg, the patient was cannulated with an RCA 6 Fr 3.5 Launcher guiding catheter, and the lesion was crossed with a Crossit XT 100 wire. The wire was parked in the distal RCA, which was serially dilated and stented with a 3 x 32 drug-eluting Bioline stent deployed at 9 atm for 10 s and postdilated to 15 atm and 10 atm with a 3.25 mm High track balloon. TIMI 3 flow was attained. There was no dissection.

It was noted that the femoral sheath was inadvertently almost out of the body, so it was pushed back into the vessel. However, the patient had severe pain at the puncture site, and a check shot showed that there was extravasation of blood from the femoral artery, out of the sheath into the subcutaneous plane (Figures 1 and 2). The patient had severe hypotension, so although we called the vascular surgeon, we thought we should tackle this by endovascular means.

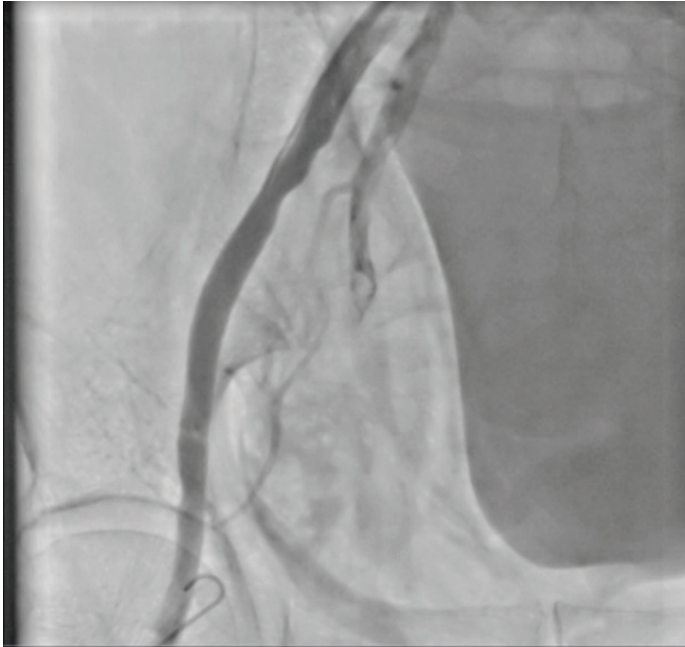


Figure 1. The indentation of the bladder is shown exhibiting the extravasation from the femoral artery.



Figure 2. The extravasation caused by the sheath breaching the right femoral artery is shown.

THE BAIL-OUT PROCEDURE

The sheath in the right femoral artery was retained. A puncture was made in the left femoral artery, and a sheath and a 6 Fr RCA catheter was placed in the right external iliac artery; repeat injection showed continued extravasation through the dissection in the common femoral artery (CFA). An exchange-length guidewire was placed in the dissection, and a peripheral balloon was tracked over this and the balloon was inflated over the perforation for 4 atm for 10 minutes (Figure 3). A second check shot showed the extravasation continued. Then, a 0.014" BMW guidewire was passed through the femoral access into the extravasation aneurysmal sac.

A glide catheter 4 Fr was threaded over the guidewire, and gel foam mixed with contrast was injected into the aneurysmal sac (Figures 4 and 5).

Details of how to embolize the femoral artery rent with gel foam: We used the antegrade approach. Abgel absorbable gel foam (Sri Gopala Krishna Labs) is a sterile, hemostatic, absorbable gelatin-based foam that is specially prepared for surgical use. Two 80 x 50 x 10 mm pieces of Abgel were scraped into tiny pieces with a sterile scalpel and mixed with about 1–3 mL contrast; 0.5 mL of this solution was then injected through the microcatheter/glide catheter into the rent. Prior to this, a little contrast was injected into the microcatheter to ensure the tip of the glide catheter was outside the femoral artery and the contrast was flowing only into the subcutaneous space. The 0.5 mL of gel foam/contrast mixture was then injected and a cine loop image was obtained.

Following this, another prolonged balloon dilatation was performed at 4 atm for 10 min. Subsequently, a retrograde injection from the left side was made to the right femoral artery to ensure that no gel embolization or obstruction to flow in the main femoral artery had occurred.



Figure 3. The persistent leak from the femoral artery after the first balloon occlusion of 10 min is shown.

Since the microcatheter has only a very small lumen, and we had verified that the catheter tip is outside the vessel, the chance of distal embolization to the right femoral artery was minimal.

We had earlier used this technique to close a perforation in a coronary artery. In 2013, we had a perforation of the proximal RCA that occurred due to a wire during a CTO intervention; we embolized a small acute marginal branch of the RCA. The patient

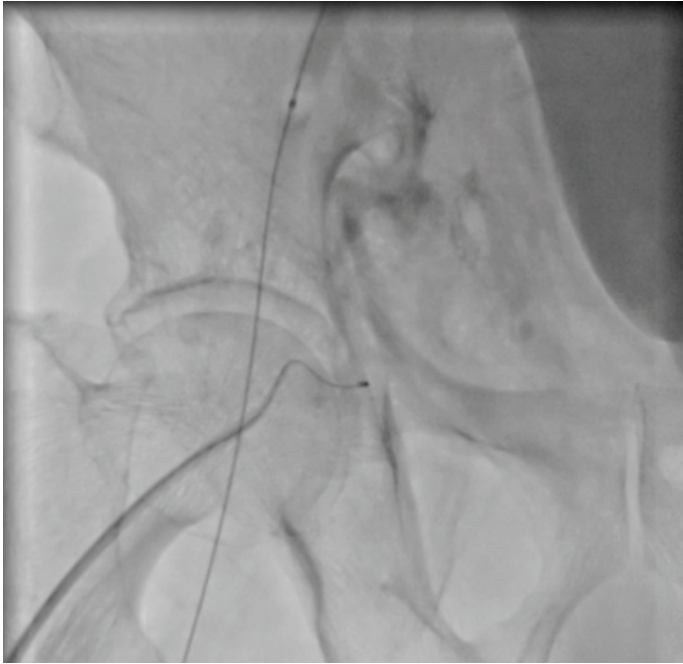


Figure 4. A glide catheter through the rent.

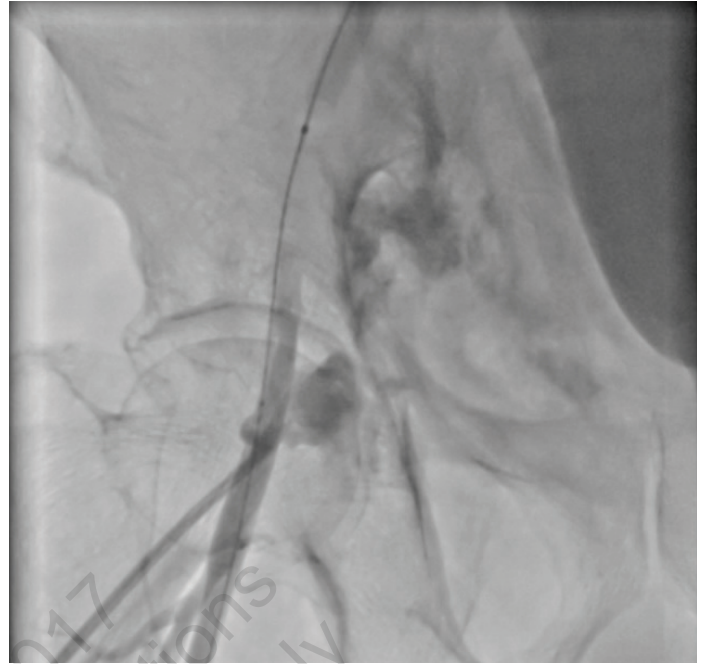


Figure 5. The gel foam/contrast mixture was injected outside the femoral artery via the glide catheter.

survived (subsequently we had a few more perforations but these were covered with the Prograft, or coils). So we attempted this in an effort to save the patient, whose blood pressure was very low. Since he was a post-CABG patient we thought his vessel would already have been damaged by the previous angiogram done before the bypass surgery (the previous angiogram was not performed by us).

There was a small leakage seen after this from the right SFA (Figure 6). On waiting further, no further dye leakage was seen on the last check shot (Figure 7). The patient remained stable hemodynamically, and a follow-up ultrasound was performed. This showed a small hematoma in the right femoral area of 5 x 5 cm. However, the patient improved and was discharged after a course of antibiotics (total hospital stay after the procedure was 9 days).

DISCUSSION

Retroperitoneal bleeds can occur after percutaneous intervention from the femoral route. Trimarchi et al report the incidence in 112,340 patients who underwent PCI from the femoral route between 2002 and 2007. Of these patients, 0.4% developed a retroperitoneal bleed; of these, 482 (6.64%) died. This was more than those who did not develop retroperitoneal hematomas (1.07% died; $P < .001$). Those with retroperitoneal hematomas also developed more postprocedure myocardial infarction, heart failure, infection, sepsis, and contrast nephropathy. Strangely, they also developed more gastrointestinal bleeding.²

Trimarchi et al relate that bleeding in a retroperitoneal hematoma is usually insidious and not recognized in the early stages. Later death can occur due to rapid exsanguination.² This is akin to what happened in our patient, and so we did not wait for

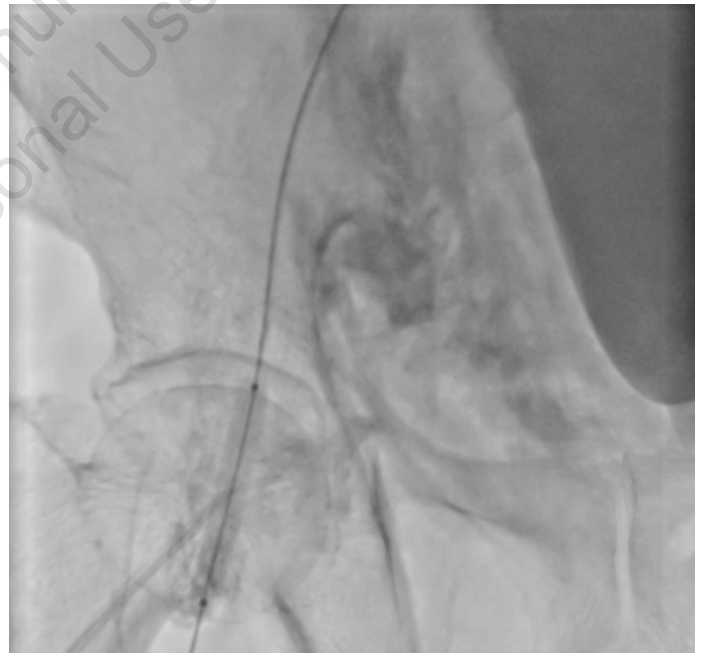


Figure 6. Persistent leak after the second balloon dilatation.

the surgeon who was present within minutes in the cath lab to intervene but used the technique described above.

Bernardo described an interesting algorithm for suspecting and managing vascular bleeds after percutaneous coronary intervention (PCI).³ He described how a retroperitoneal bleed should be suspected when the patient has the following: (1) a vagal reaction to palpation of the access site, or pain; (2) response to hypotension

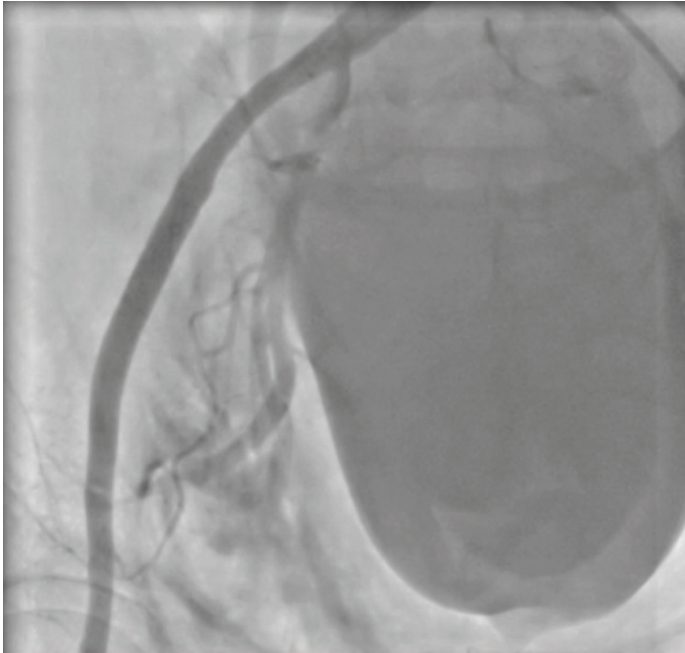


Figure 7. After the third balloon dilatation, no further leak or extravasation was seen.

when fluid resuscitation is given; (3) hypotension or a systolic blood pressure of <30 mm Hg from the baseline systolic blood pressure, or an absolute blood pressure of <90 mm Hg.

Ongoing myocardial ischemia, tamponade, or myocardial infarction should be rapidly considered and ruled out. Bernardo advocates fluid replacement, serial hemoglobin estimation, and blood transfusion. He also recommends rapidly taking the patient back to the cath lab and looking for a bleeder, as computed tomographic scan of the abdomen may be too late. With this protocol, no patient dies or needs to discontinue antiplatelets, which is fatal in a stented patient. He also demonstrated the use of local thrombin injections into the hematoma site, akin to what we describe.

In our case, the patient developed the complication before he left the lab. We discovered the “indented bladder sign” early after the PCI, so we did a check injection immediately after the patient complained of pain and distress, when the sheath was reintroduced.

Relevant anatomy of a retroperitoneal hematoma:⁴ The use of bivalirudin has been shown to prevent the development of retroperitoneal hematomas.² Preventing a retroperitoneal hematoma is as relevant as treating one. Thus, it is worth reviewing the anatomy of the groin vessels. Topol et al have reviewed this elaborately.⁴ Briefly, they describe that the external iliac artery becomes the CFA when it crosses below the inguinal ligament. Then, it runs for about 1 cm and divides into the superficial femoral artery and the profunda artery. Inadvertent punctures in the profunda femoral artery usually lead to pseudoaneurysms as the vessel is not supported by the femur.

Approximately 1 cm below the imaginary line between the anterior superior iliac spine and the pubic tubercle is the place to

puncture the femoral artery. Visualizing the lower inner quadrant of the femoral head while puncturing prevents high punctures.

Usually a retroperitoneal hematoma can occur in two ways: (1) the needle perforates the posterior wall of the femoral artery during the Seldinger technique; and (2) the puncture is too high. The main cause of retroperitoneal hemorrhage is that the femoral artery is punctured above the inguinal ligament. The landmark advised to avoid high puncture is that the puncture should be below the origin of the inferior epigastric artery. A puncture above the origin of the inferior epigastric artery goes through the various layers of the abdominal wall, leaving a lot of lax tissue where blood can collect insidiously. When a sheath is introduced through a high puncture it goes through the fascia of Campa and fascia of Scarpa, then through the internal and external oblique abdominal muscles.⁴ Our patient had a blood pressure of 40 mm Hg once the rent occurred, and might have expired if we had waited. Furthermore, the lower blood pressure would have caused stent thrombosis. Therefore, although we started noradrenaline and dopamine, we decided that we could not wait for a surgical management of this potential retroperitoneal hematoma. We have previously used gel foam for one of our coronary perforations, and the patient survived.

A technique similar to the one we describe has already been reported by Nguyen et al.⁵ The authors describe how a retroperitoneal hematoma should be suspected if there is flank pain, hypotension without an apparent reason, and iliopsoas spasm. This presents as severe pain in the right hip on trying to extend the hip. Compression of the femoral nerve can occur and causes paresthesia at the front of the thigh, and weakness of the quadriceps, sartorius and iliopsoas muscles. Reversal of heparin and fluid replacement are recommended as an emergency. Open surgery may be harmful as the hematoma has a compressing effect slowing the bleeding. If the bleeding is heavy, they recommend selective cannulation of the mouth of the inferior epigastric artery and coronary balloon inflation for 4 times over a period of 20 min via a crossover puncture from the left femoral artery. Nguyen et al describe the use of a 0.014” BMW coronary wire and a 2 x 10 mm balloon inflated to 1 atm until bleeding stops, with the balloon placed at the origin of the inferior epigastric artery rather than in the external iliac/femoral artery. If the bleeding persists, they advise coil embolization or injection of thrombin (we did not have these in our lab). The coils or the thrombin are injected into either the deep circumflex iliac artery or the inferior epigastric artery if these vessels are found to be bleeding continuously.⁵

Causation of the bleeding by a guidewire: When a stiff, short guidewire with a large J curve is introduced into a small vessel and is forcibly pushed, the smaller branches of the vessel can be damaged.⁵ These vessels are damaged by the guidewire when the femoral artery is small and the guidewire is forced into the side-branch artery and the wire has a large J tip. Pushing the guidewire forcibly causes perforation of the smaller branches of the external iliac artery, the deep circumflex iliac artery or the inferior epigastric artery.⁵

As we have shown, bladder compression is a sign of extravasation of blood, but this occurs relatively late after a large volume of

blood is lost. So in our patient, a relatively large volume of blood may have collected rapidly to cause profound hypotension and bladder compression.⁶ Authors have commented that finding the bladder sign in the cath lab allows early detection of a retroperitoneal hematoma and endovascular treatment of the same.⁷ They and previous authors have called this the dented bladder sign. Routinely looking at the bladder by fluoroscopy for the dented bladder sign after femoral access and a prolonged procedure may prevent late morbidity and mortality from a retroperitoneal hematoma.

Iatrogenic rents in arteries are rarely reported. In one case, an inadvertent rent in the right subclavian artery had been made when an internal jugular cannulation was attempted without ultrasound guidance.¹ The patient was in cardiogenic shock and had adverse bleeding parameters (like a low platelet count), so the rent was closed by a Perclose ProGlide Suture Mediated Closure (SMC) System (Abbott Vascular) that is generally used for femoral artery closure after percutaneous intervention.

This device has to be avoided in tortuous femoral arteries and calcified femoral arteries. Furthermore, it should not be used when the femoral puncture site is close to a bifurcation (<1.0 cm). This is because using the Perclose in this position would result in pseudoaneurysm, thrombosis, or dissection of the vessel. In the case described above, the following procedure was followed. A subclavian angiogram was taken from the femoral route (puncture). This showed that the vertebral artery arose well away from the rent in the subclavian artery. A 0.035" angled Amplatz stiff wire (Cook Medical) was passed through the central venous catheter and placed across the descending aorta. The CVP catheter was removed, and a 6 Fr Perclose device was introduced over the guidewire. The suture was deployed as usual, and the knot was tightened by the knot pusher. A repeat angiogram showed the extravasation had stopped. The knot was then cut.

Transcatheter embolization of bleeding arteries is becoming increasingly common – especially after trauma, where the patient is unstable, urgent closure is required, and the vessel is expendable, where closure will not cause ischemia or gangrene.⁸ Metallic coils, gelatin sponge (as we used), or detachable coils have to be used. Polyvinyl alcohol (PVA), microspheres, Onyx liquid embolic agent, and N-butyl cyanoacrylate (tissue glue) can also be used in injuries but are less commonly used. PVA, Onyx, and tissue glue cause permanent occlusion, whereas the gelatin sponge usually recanalizes within 1 or 2 weeks.

We did not use a covered stent, as we did not have the correct size with us. Furthermore, we thought this might cause limb ischemia.

The current case was an accidental rent in the femoral artery, again reminding us of an important lesson. All manipulations in the groin should be done over a guidewire. By pushing the arterial sheath into the artery without a guidewire, we made a rent in the femoral artery that would have caused the patient to rapidly bleed to death. We report this complication and its solution to prevent similar errors.

We reviewed the literature of other femoral artery breaches and came across a few interesting articles.³ Other conditions where the femoral artery tears or ruptures spontaneously have been due to osteochondroma.⁹ Goyal et al report that they treated a case where

the osteochondroma eroded the femoral artery spontaneously. The patient was ultimately treated by femoro-femoral bypass. They demonstrate a huge contained hematoma in the leg, and have also described ruptures of pseudoaneurysms in the brachial arteries, tibial arteries, and peroneal arteries due to osteochondroma.

Commonly, pseudoaneurysms of the femoral artery occur in chronic haemodialysis patients. This has been described in studies from both Nigeria and India.^{10,11}

Covered stents have been used to close pseudoaneurysms of both the right subclavian artery and the femoral arteries.^{12,13}

Thalhammar et al describe the endovascular management of 29 cases of femoral pseudoaneurysm/arteriovenous fistula.¹³ They utilized covered stents to treat these patients. Twenty-six of 29 cases were successful, but 1 patient had stent thrombosis immediately after deployment; this patient had to be thrombolyzed and later developed a subdural hematoma. On further follow-up, 4 more cases developed stent thrombosis (17%). Loss of side branches of the femoral artery was one of the other asymptomatic complications seen by this team. Thus, covered stents are not always the answer to iatrogenic tears in the femoral artery.

Spontaneous adrenal artery bleeding has been successfully embolized to control arterial bleeding.¹⁴ Possibly if embolization had not been done, the patients would have bled to death.

Risk factors for retroperitoneal hematomas:² Trimarchi et al found that female sex (odds ratio, 3.44; 95% confidence interval, 2.73–4.34) predicted the chance for retroperitoneal hematoma ($P<.001$). A body surface area of <1.8 m² also predicted retroperitoneal haematoma ($P<.001$). Strangely, history of obstructive pulmonary disease was a predictor of retroperitoneal bleeding.

Certain procedural features were also associated with an increased chance of retroperitoneal bleeds. These were emergency PCIs, those with cardiogenic shock, preprocedure use of heparin, pre-procedure use of glycoprotein IIb/IIIa inhibitors, use of closure devices, and a larger sheath size (>8 Fr). In general, using a 6 Fr sheath is safer than using a 7 Fr or 8 Fr sheath, even for femoral procedures.

Nikolsky et al validated a prognostic risk score for predicting major bleeding during percutaneous intervention via the femoral route.¹⁵ This score included up to 10 points, of which 5 points were given for use of an intraaortic balloon pump. Age up to 55 years was given a score of 0 and thereafter every 10 years was given a score of 3. Female gender was given a score of 3, glycoprotein IIa/IIIb inhibitors were given a score of 3, and a reduced glomerular filtration rate was given a score of 2 (<60 mL/min/1.73², as estimated by the Modification of Diet in Renal Disease formula). Anemia (hematocrit <39% for men and <36% for women) and use of low-molecular-weight heparin within 48 hours before PCI were the remaining predictors; each was given a score of 2. Those with a low score (zero) had a bleeding rate of 1.3% vs those with a risk score >10. A major bleed occurred in 5.05% of these high-risk individuals.¹⁵ Senior workers have commented that bleeding increases the hospital costs and is associated with almost 3.5 times higher mortality.¹⁶

Predictors of mortality in retroperitoneal bleeds: Trimarchi et al² found the predictors of mortality to be female sex,



Figure 8. The type of gel foam used for embolization..

history of myocardial infarction, cardiogenic shock, preprocedural serum creatinine >1.5 mg/dL, and reduced left ventricular ejection fraction. These were independent predictors of death, but strangely each factor does predict an increased mortality from any PCI independently.

VCD closure and failures:¹⁷ Vascular closure devices are very convenient for closure of the femoral artery and early ambulation, but if they fail the outcomes are dismal. In a large series of 9823 patients in whom vascular closure devices were used, 268 (2.7%) failed. The failed patients had an increased incidence of major vascular complications (1.9% vs 0.6% in those with successful vascular closure; $P<.01$).¹⁷ They also had greater chance of surgical repair of their femoral arteries, pseudoaneurysm, groin bleeding, hematoma (4.5%), retroperitoneal bleed, and limb ischemia. The authors also compared the use of a suture-based closure device (Perclose) vs a collagen-plug device (Angio-Seal). After propensity matching, they found more failures with the Perclose device.

Embolization with thrombogenic material: Thrombogenic material can be embolized when: (1) the area to be embolized is not crucial; (2) the area in question is an end artery; and (3) rapid treatment of bleeding is required. As mentioned above, Abgel (Figure 8) is a readily available tool frequently used by surgeons to prevent bleeding.

CONCLUSION

Massive exsanguination from the femoral artery or other large arteries can be rapidly fatal. We describe here an emergency measure to stop bleeding from a rent in the femoral artery. We successfully injected contrast with gel foam bits into the rent into the subcutaneous tissue and stopped the bleeding. We report this to help others. ■

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