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Closing with confidence in vascular surgery

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Doppler ultrasound can provide a cost-effective tool in ensuring verification of vascular blood flow during vascular surgery, enabling surgeons to 'close with confidence'. So, should the philosophy shift towards physiologic assessment first and imaging second?

How can we 'close with confidence'? This is the key question faced by surgical teams when performing vascular procedures. Quality control is vital when performing surgery, if secondary intervention and re-operation are to be avoided. Reliable and safe verification of vascular blood flow, during surgical procedures, gives surgeons the reassurance they need that the procedure has been performed satisfactorily. But what is the optimum method for completion quality assessment and what is actually happening in practice?

Currently, the main options available include pulse palpation; completion angiography; intraoperative Duplex ultrasound; Intraoperative Doppler and other technologies. The pros and cons of these various approaches are shown in Table 1.

The guidelines

Both the European Society for Vascular Surgery and the Society for Vascular Surgery have produced guidelines on many vascular procedures, including managing acute and chronic limb ischaemia, carotid artery disease and mesenteric artery disease.[1,2] All recommend some sort of assessment after the arterial reconstruction has been completed, mostly suggesting that angiography or Duplex ultrasound are used.

"Often guidelines do not describe the real-world complexity of our practice," comments Mr Lukla Biasi, a Consultant Vascular Endovascular Surgeon at St Thomas'. "Guidelines are both a comfort zone and quicksand for surgeons; there is no 'one size fits all', and guidelines are often outdated, as they are the result of a long process of agreement and medical research," he warns.

He calls on the surgical community to improve the strength of evidence around international recommendations for completion quality assessment in vascular surgery and highlights a need to "introduce intraoperative Doppler into the narrative of the guidelines."

Mr Lukla Biasi points out that we also need to be aware that catheter directed angiogram comes with a risk of complication itself (i.e. a 1% risk of stroke).

"For acute ischaemia, the recommendation is to try to integrate the procedure into a hybrid [theatre] setting, where we can perform open surgery, endovascular treatment and completion angiogram. In practice, this is not always the case. Often interventions are performed out of hours and not in the ideal setting. Performing a completion angiogram is not always feasible or time-effective, plus there is a risk of contrast-induced nephrotoxicity," he explains.

Before the advent of Doppler technology, traditional methods of assessing blood flow required invasive procedures like injecting the vessel and taking X-ray pictures, which carries a risk of complications. The Dopplex probe, for example, offers a non-invasive alternative, reducing these risks significantly. It can provide immediate evidence of success in vascular reconstructive procedures. By confirming blood flow prior to closing, time and costs of a potential re-operation can be saved. This approach can offer surgeons real-time confirmation of vascular patency during operations, providing reassurance and eliminating guesswork.

Doppler ultrasound can be used in a wide range of clinical procedures, including carotid endarterectomy, femoro-popliteal bypass, femoro-distal bypass, arteriovenous fistulae, coronary artery bypass grafts, renal and hepatic transplantation, aortic aneurysm repair, cosmetic surgery and skin flap surgery.

Visualising pulse waveforms

Professor Usman Jaffer, an Honorary Consultant Vascular Surgeon, Imperial College Healthcare NHS Trust, asserts: "People talk about 'a must have' or 'a nice to have'. As shown by our data around peripheral arterial disease detection,[3] in people with diabetes, Doppler is very much in the 'must have' category, rather than the 'nice to have'."

Prof. Jaffer highlights an example of how the technology is used during femoral endarterectomy. The common femoral artery, located in the groin, supplies blood to the thigh and calf. When this artery becomes obstructed with calcified material, or atheroma, it impedes blood flow, risking tissue damage and other serious health issues.

Without precise and reliable tools to assess blood flow, surgeons can face challenges in confirming the success of procedures like bypasses and endarterectomies. Inadequate blood flow can lead to prolonged recovery times, increased risk of complications, or the need for ▶

repeat surgery.

Prof. Jaffer uses Dopplex ultrasound to ensure the technical soundness of his procedures. The latest technology provides both an audible waveform signal, as well as digital waveform images, to provide extra diagnostic information. Waveforms can also be saved and exported to be included in the patient record.

The system can be used for pre-, peri- and post-operative assessments simply by changing the probe being used. Both clinicians and patients then benefit from being able to accurately track outcomes with consistency.

"There is a concept of non-destructive testing during surgery," Prof. Jaffer comments. "You need to know what's going on; it's not good enough to have performed the procedure - you need verification that everything is ok. In healthcare, we have developed ultrasound to perform this role. The advantage of this handheld Doppler device is that it offers you a test that that reports immediately. You just switch it on and go. There are more complicated tests with bigger ultrasound machines, but they are not as immediate in terms of feedback."

According to Prof. Jaffer, "The technology gives rapid results, with very fast feedback, but it also gives a visual waveform, which gives more certainty in terms of what you are looking at. In the past, Doppler machines were just audible, but there's a lot of guesswork around listening and characterising the audible Doppler signal... We have published research that shows that a visual signal is much better than just an audible signal."[3]

During a common femoral endarterectomy, the Dopplex surgical probe detects triphasic signals, indicating healthy blood flow patterns. These signals are crucial for verifying that both inflow and outflow are adequate.

"If it is triphasic we are extremely pleased; if it isn't triphasic, we want to find out why and correct the problem," says Prof. Jaffer.

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He points out that Doppler monitoring not only enhances safety but contributes to efficiencies in the theatre: "If you are sure that the bypass or patch plasty is working well, you can close up quicker and move on to the next case. Feeling confident rather than waiting another 20 minutes to see if it's still ok, means there is the potential to reduce waiting times," he explains.

Prof. Jaffer reveals that he has adopted single-use intraoperative probes into his practice, which is not only important from an infection prevention perspective, but also avoids reliability issues associated with wear and tear caused by repeated reprocessing: "Poor care costs a lot more than good care, so it is important to deliver good care as many times as possible – first time. If that requires a single-use piece of equipment and you know it is going to work, that pays dividends in the medium to long-term," he concludes.

An essential part of 'standard practice'

Professor David Bosanquet, a Consultant Vascular Surgeon at the South East Wales Vascular Network, University Hospital of Wales, also considers the Doppler probe an essential tool in vascular surgery. Prof. Bosanquet specialises in a wide range of arterial operations, including bypasses, revascularisation of legs, open and endovascular aortic surgery, carotid surgery, and amputations.

"A lot of what we do in vascular surgery is about achieving better flow past blockages, through a variety of different ways – it may involve the use of a balloon to pull out a clot, inserting stents or performing a bypass. If you have a small technical issue, the vein or artery isn't good enough, or if the flow isn't good enough, it may block off in recovery, the next day, or in a few days' time," he explains.

"When you have performed a bypass from the groin artery to the knee artery, and you take off the clamps, you will be able to see pulsation within the vessel, and you will be able to put your finger on it and feel it. While it provides you with some information that pressure is coming down the vessel, you cannot be certain that there's actual flow.

"The kind of pulse you want isn't necessarily a really strong one – sometimes this can imply that it is 'hitting a wall' – there may be an

occlusion causing resistance at the bottom end. What you want to see is a pulse that 'comes up' and then 'goes down', because it's flowing away."

Prof. Bosanquet points out that a surgical probe is more effective in decision-making than palpating with a finger: "We know that a pulse is not good enough – you should use a Doppler, so that you can see, hear and evidence that there is flow past the surgery. This week, I have performed an emergency operation, two major revascularisations and two big cases – I used the Doppler to complete every single one. I don't see it as anything other than being standard practice, now."

The probe ensures that patients are not sent to recovery with a failing graft, offering rapid, reliable, and easy-to-use confirmation of successful blood flow. This confidence in the probe's effectiveness is crucial for the surgical team's decision-making and patient outcomes.

He gives the example of a case study in which he needed to get blood flow down both of the patient's legs. At the end of the procedure, blood was flowing satisfactorily down one side, but for the second limb, the picture was less certain. In this situation, he needed to decide whether to use a plastic tube from the 'good side' to the 'bad side', or whether the flow was in fact adequate.

"To decide if I have achieved sufficient flow, I looked at the foot. I felt the pulse, but I also used the Doppler. What I found was that, although there was a very faint pulse, it was not sufficient – I needed to go on to do more. If there is a problem, you can fix it on the table.

"The winners are the patients, as you can give them the best operation," Prof. Bosanquet continues. "If a graft fails in recovery, and you have to bring the patient back, not only is that a significant burden to the patient, but you're essentially doing an emergency case – when everyone should be moving on to the next patient. That's where the savings are; you're not bringing patients back to theatre," he comments.

The technology has other useful applications in vascular surgery – Prof. Bosanquet explains that Doppler ultrasound can prove helpful in locating a vessel when dealing with anomalies. He cites a case where a bypass graft was inadvertently tunnelled through a muscle, which caused it to pinch each time the knee was bent.

"If you're looking in the middle of a muscle and not at the normal anatomical place, the vessel may not be immediately apparent. In a challenging scenario such as this, the surgeon can direct the Doppler probe at different angles and different locations to help them identify exactly where the abnormally placed artery is located," he explains.

Pulse palpation

The **pros** of pulse palpation (within the operative field, in the distal limb) include:

- Immediate
- Free, easy to do, simple
- Part of standard surgical teaching

The **cons** of pulse palpation include:

- Difficult/impossible to palpate distal pulses in certain circumstances
- Can be present despite occluded graft
- No way of ascertaining graft at risk
- Subjective

Completion angiography

The **pros** of completion angiography include:

Detects technical issues immediately (e.g. stenosis, poor flow).

- Allows intraoperative corrections
- Provides documentation for quality assurance

The **cons** of completion angiography include:

- Adds time to the procedure
- Adds/increases radiation exposure
- Risk of contrast-related complications (e.g. nephrotoxicity)
- Higher cost and resource use

Intraoperative Duplex ultrasound

The **pros** of Intraoperative Duplex ultrasound include:

- Non-invasive and radiation-free
- Real-time haemodynamic assessment
- Detects residual flow abnormalities
- Useful in carotid endarterectomy (CEA)
- Portable and repeatable

The **cons** of Intraoperative Duplex ultrasound include:

- Operator-dependent accuracy
- Limited anatomical detail
- Inconsistent evidence on long-term outcomes
- May miss subtle defects in deep or calcified vessels

Intraoperative Doppler probe assessment

The **pros** of intraoperative Doppler probe assessment include:

- Immediate feedback on blood flow – confirms graft patency and vessel perfusion
- Audible and visual signals enhance surgeon confidence
- Non-invasive and sterile – single-use probes reduce infection risk
- Useful in small vessels - micro-Doppler ideal for vessels <2-3mm
- Portable and easy to use – direct application to vessels

The **cons** of intraoperative Doppler probe assessment include:

- Limited anatomical detail – cannot visualise vessel structure
- Operator-dependent interpretation – requires experience
- No quantitative flow data – qualitative assessment only
- May miss subtle abnormalities in deep or calcified vessels

Table 1: The pros and cons of the different approaches used for completion assessment

Post intervention assessment

Discussing post intervention assessment, Dr. Leigh Ann O'Banion, Associate Clinical Professor in the Department of Surgery, University of California San Francisco, Fresno Branch Campus, comments that, "The success of the first operation matters the most. You need to leave the operating theatre knowing you have performed a technically perfect operation. There are various ways you can do that – one is a post intervention Doppler assessment, which allows audible feedback distal to the intervention (including monophasic, multiphasic, water hammer). An interoperative Doppler assessment is the perfect way to start, once you have completed your bypass."

She comments that it is important for less experienced surgeons to practice listening to the sound of the triphasic signal to ensure they are familiar and 'tuned' into the different Doppler signals they will hear. However, she adds that it is also important to see the waveform, where possible.

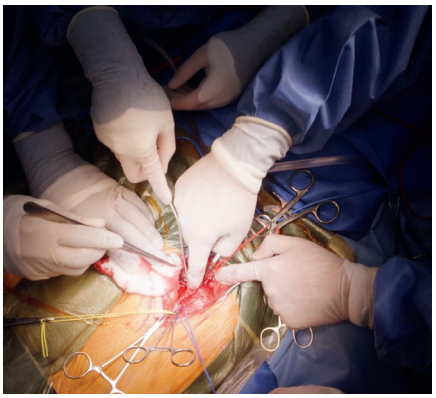
"Having completion Duplex ultrasound can also be really valuable to gaining a better understanding of the haemodynamics...

"We need to think about ultrasound in the same way for open procedures, as we do for endovascular. Sometimes, it can be quite challenging to identify the location of the pathology, but you get a little more information than the Doppler alone."

Dr. Leigh Ann O'Banion says that she uses completion angiogram for tibial cases, tenuous vein, or if there is a concern with the clinical examination. However, angiograms can be misleading, she points out: "You may think the outflow doesn't look good, but when you complement the angiogram with interoperative Duplex, you may find it is just spasm," she ▶

explains. "This is very common in arteries that are heavily calcified. Therefore, I think completion angiogram needs to be used in the context of the other information that you get from the Duplex or Doppler.

"There are a lot of studies that have shown that completion angiogram and completion Duplex ultrasound can predict early graft thrombosis particularly in patients with below-the-knee bypasses. Therefore, in my practice, this data has driven me to use a combination of completion angiogram and completion Duplex ultrasound. If I'm in a hybrid room, I tend to use angiogram, but if I'm not in a hybrid room, I tend to use ultrasound to look at the anastomosis. If you are concerned about the vein conduit, then a completion angiogram and intraoperative intravascular ultrasound (IVUS) are the best way to go, as it's hard to Duplex the entire vein. But all of this



is complementary to using an intraoperative Doppler. This is my first 'go to', as soon as I'm done with the bypass," she concludes.

Real-world practice

Professor Athanasios Saratzis, NIHR Research Professor of Vascular Surgery, University of Leicester, acknowledges that there is a lack of major Randomised Control Trials (RCTs) on outcomes for completion assessment angiography and completion assessment using Doppler, but comments that, "sometimes you just need to employ common sense."

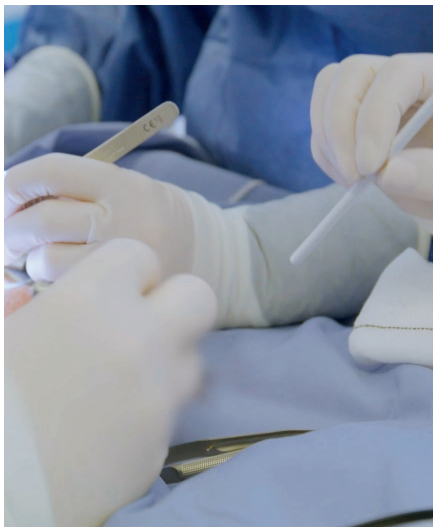
He points out that across the available observational studies:

- Routine completion angiography does not consistently improve outcomes in Peripheral Artery Disease (PAD) surgery.
- Intraoperative Doppler is reliable, quick, non-invasive and identifies most technical issues.
- Selective imaging guided by abnormal Doppler findings is safe and efficient.
- The philosophy is shifting towards physiologic assessment first, imaging second.

Therefore, he concludes that the clinical implication is to use intraoperative Doppler as the primary completion check, reserving completion imaging for abnormal findings or case uncertainty. However, there appears to be a gap between the guidelines and what happens in real-world practice, as a survey of vascular surgeons reveals. (See figures 1-4) When asked about their practice at completion for a specific case study scenario, nearly one-third had never used completion angiogram, nearly half had never used intraoperative Duplex, only 13% always used intraoperative Doppler probe assessment, while the majority (67%) always used pulse palpation.

"The guidelines say, 'always do a completion angiogram or Duplex', yet we do not have the best evidence out there, and surgeons don't always perform completion angiograms. So, what needs to change?" questions Prof. David Bosanquet. "Do the guidelines need to change to reflect clinical practice, or does clinical practice need to shift more towards the guidelines?"

"As physicians, especially when working in



Completion assessment: what happens in practice?

During a recent webinar, hosted by Huntleigh, attendees were asked about their current practice. Case: **femoro-BK popliteal graft**, with three vessel runoff, using ipsilateral LSV, completed without incident. Arterial clamps have just been removed. What would you do? Below are the results of the survey:

Fig. 1

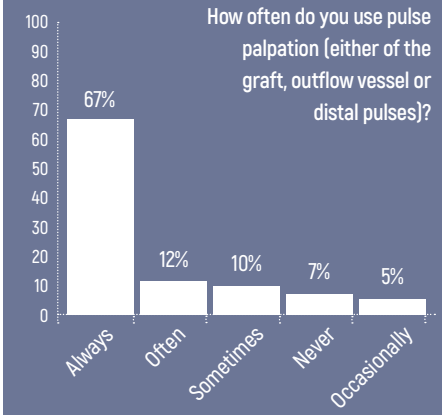


Fig. 3

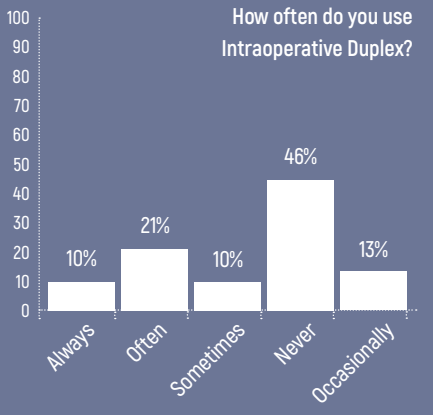


Fig. 2

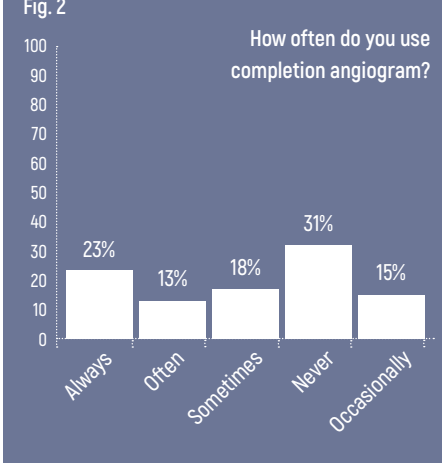
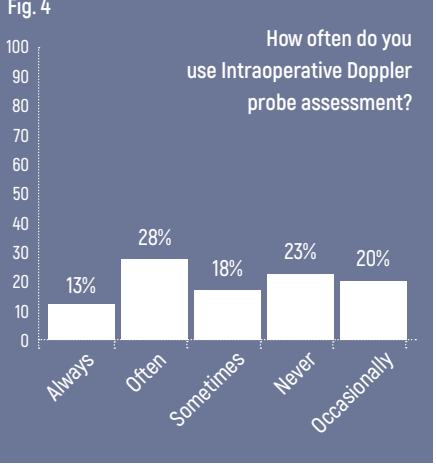


Fig. 4

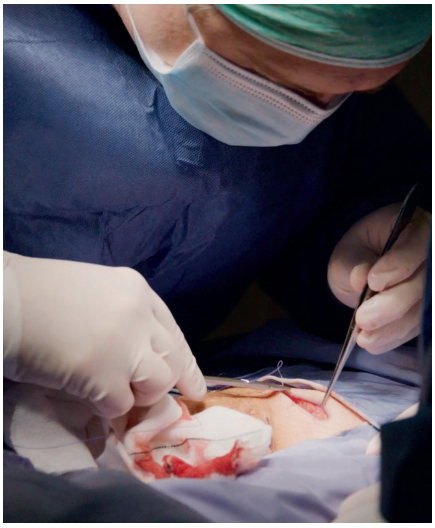


high volume centres, we have a responsibility to provide the evidence," says Mr Lukla Biasi. "Guidelines are there to bring us together as a group of physicians. We need to educate, collect the data, and inform the guidelines. The guidelines do not consistently mention intraoperative Doppler, and yet we have demonstrated that it is fundamental to first line assessment."

Conclusion

"An intraoperative Doppler is cheap, it's fast, it's reliable, and at a bare minimum should be the bar for evaluating a bypass...We should be doing more than just pulse palpation," concludes Dr. Leigh Ann O'Banion.

Ultimately, intraoperative Doppler probes, when used for patency assessment at the time of revascularisation surgery, can help surgeons 'close with confidence'. However, there is wide variation in completion assessment practices, across healthcare providers, and a need for the vascular surgery community to come together to inform future guidance. **CSJ**



Intraoperative Doppler probes, when used for patency assessment at the time of revascularisation surgery, can help surgeons 'close with confidence'

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Further reading

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SCAN ME

An educational webinar, sponsored by Huntleigh, explores these themes and issues in more depth, including clinical case studies from top vascular surgeons. To view the webinar, *Patency Assessment at the Time of Revascularisation Surgery: How to Close with Confidence*, scan the QR code above.