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In this issue ...

**Intraoperative CO₂
angiography of
arteriovenous fistulae**



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Intraoperative CO₂ angiography of arteriovenous fistulae

By combined use of the advanced C-arm, the latest software and a microprocessor-controlled dose injector, it is possible to obtain high-quality intraoperative CO₂ angiograms quickly and without risk of complications, especially in patients suffering from renal insufficiency

Use of carbon dioxide (CO₂) as a contrast medium in angiographic imaging began in the 1970s. Once the technique of digital subtraction angiography (DSA) along with electronic contrast enhancement had found general acceptance, numerous studies were undertaken aimed at ensuring its safe use and expanding its range of applications.

A major problem has always been exact dosage and pressure control, which are crucial for its safe administration. For lack of suitable technologies, CO₂ has been administered until now by means of self-made or commercially available manual injection systems (Figure 1). A major shortcoming of this method, however, is the fact that these systems are often complicated to fill and an exact dosage of the total and per-time gas quantity is impossible.

Due to the high compressibility of this gas, a major quantity escapes under high pressure at first, and thereafter both gas quantity and gas pressure are decreasing. Contamination from ambient air may only be avoided by proceeding with extreme care, but can never be excluded with certainty.

Moreover, to date only stationary DSA systems have been equipped with suitable software for CO₂ angiography, and its intraoperative use has been limited on account of the typical features of C-arms.

Properties of CO₂

- High solubility – 20 times higher than that of oxygen (O₂).
- Highly compressible.
- Low viscosity.
- Immediate dissolution in blood plasma; catalysed by the enzyme carbonic anhydrase (CO₂+H₂O); carbonic acid is formed, which immediately dissociates into

H⁺ and HCO₃⁻ and dissolves in plasma.

- Single-pass elimination through the lungs approx. 12–15 s after IV administration.
- Gas buoyancy.

Advantages over conventional contrast media

- Non-iodine-based.
- Non-allergenic.
- Hence no contraindications such as hyperthyroidism, renal insufficiency or contrast medium allergy.
- Delivery through very thin catheters possible due to low viscosity.
- Representation of even the smallest leaks and fistulae.
- Optimum imaging of collateral vessels.
- Very inexpensive.

Technical prerequisites

Malek Medical Products has been offering a microprocessor-controlled injector system for some time that overcomes the drawbacks of the previous methods of administration. The INSPECT 2005-R is a fully enclosed system, making contamination from ambient air impossible. It is equipped with a foot control, thus allowing hands-free operation (Figure 2). A dual safety system effectively prevents administration errors.

The dose amount per injection, the total dose amount and the injection pressure can be set precisely. The contrast medium is administered steadily and without any fluctuations. A sterile cover enables operation by the surgeon.

In the operating room we are using the Ziehm Vision C-arm. This new-generation C-arm features ClearView imaging technology with a high-dynamic 1 k x 1 k camera system, which clearly visualises even the tiniest anatomical

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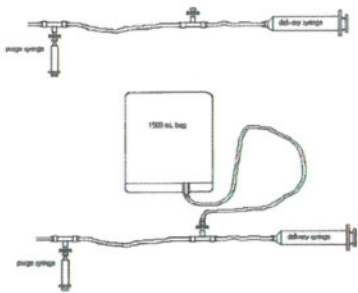


Figure 1. Conventional CO₂ delivery system

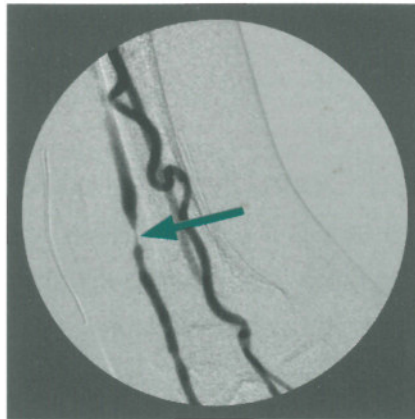


Figure 3a. Intraoperative image of an antebrachial loop shunt with high-grade stenosis to the runoff vein. The subsequent PTA was also performed with CO₂

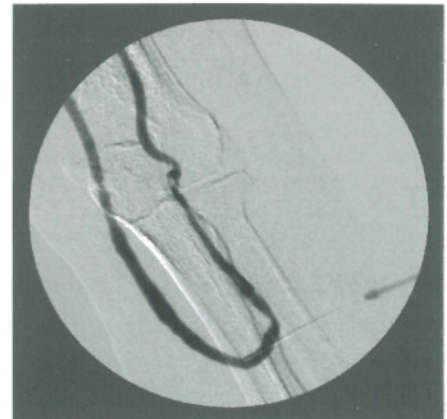


Figure 3b. Full image of an antebrachial loop shunt with 80 ml of CO₂

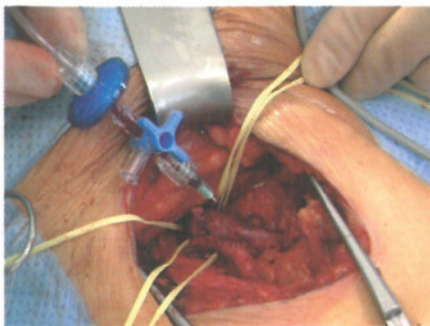


Figure 2. Intraoperative CO₂ angiography – setup

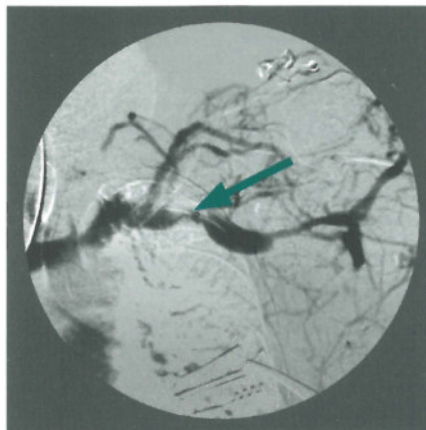


Figure 3c. Subclavian vein occlusion resulting from occlusion of an infraclavicular subclavian prosthetic loop shunt, with extensive collateralisation present

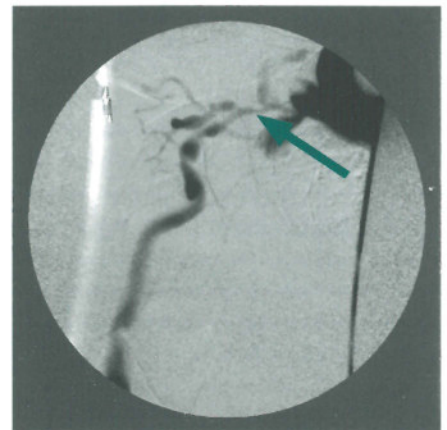


Figure 3d. High-grade central stenosis of a cephalic vein shunt. Even very central structures can be imaged perfectly with as little as 100 ml of CO₂

Further reading

- Back MR, et al. Angiography with carbon dioxide (CO₂). *Surg Clin North Am* 1998;78(4):575-91.
- Hawkins IF, et al. Carbon dioxide (CO₂) digital subtraction angiography: 26-year experience at the University of Florida. *Eur Radiol* 1998;8(3):391-402.
- Kummer-Kloess D. Interventionsbegleitende Angiographie mit Kohlendioxid bei Patienten mit erhöhtem Kontrastmittelrisiko. *Zentrbl Chir* 1997;122(9):725-9.
- Spinosa DJ, et al. CO₂ and gadopentetate dimeglumine as alternative contrast agents for malfunctioning dialysis grafts and fistulas. *Kidney Int* 1998;54(3):945-50.

structures. The VisionPulse generator technology delivers up to 30 frames per second in outstanding resolution.

The VisionCenter touchscreen control panel provides full freedom of control of any function in a logical, workflow-oriented way.

In a joint effort, an innovative software solution has been developed that offers convenient on-the-fly inversion of the negative contrast medium path as well as contrast enhancement, thus making the angiograms appear in the familiar form (Figure 3). This function can be activated by simply pressing a button on the touchscreen.

Conclusion

By combined use of the advanced C-arm, the latest software and the dose injector, it is possible to obtain high-quality intraoperative CO₂ angiograms quickly and without risk of complications, especially in patients suffering from renal insufficiency. ■