

# Carbon dioxide arteriography as a supplementary study in the detection of acute massive gastrointestinal bleeding

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**Abstract.** Purpose: To compare the diagnostic efficiency of carbon dioxide (CO<sub>2</sub>) and an iodinated contrast medium (ICM) for detection of arterial haemorrhage.

Methods and materials: Over a 24-month period, 23 patients were referred 26-times for angiography to detect arterial gastrointestinal haemorrhage. The CO<sub>2</sub> arteriography was performed only when standard ICM arteriography was undetermined or negative. The CO<sub>2</sub> arteriograms were performed using hand injections. Digital subtraction angiography with filming at 3 images per second and single frame mask without stacking of images was used in all cases.

Results: There were 3 (11.5 %) additional positive studies among 18 (69.2 %) negative ICM angiograms when CO<sub>2</sub> was used as a contrast medium.

Conclusion: CO<sub>2</sub> arteriography can detect arterial extravasation when findings of routine angiography are dubious or negative. The CO<sub>2</sub> arteriograms could not detect detailed vascular anatomy.

**Key words:** Contrast medium, carbon dioxide (CO<sub>2</sub>), digital subtraction angiography, gastrointestinal bleeding

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**Souhrn.** Cílem práce bylo porovnat diagnostickou efektivitu oxidu uhličitýho (CO<sub>2</sub>) a jodové kontrastní látky (ICM) při diagnostice arteriálního krvácení.

Metodika a sestava nemocných: v průběhu 24-měsíčního období bylo 23 pacientů odesláno celkem 26-krát k angiografii k objasnění zdroje arteriálního gastrointestinálního krvácení. CO<sub>2</sub> arteriografie byla provedena, pokud byl nález standardní ICM arteriografie neurčitý nebo negativní.

Výsledky: Při použití CO<sub>2</sub> jako kontrastní látky bylo vyšetření pozitivní ve 3 případech (11,5 %) z 18 (69,2 %) dříve provedených negativních ICM angiografií.

Závěr: CO<sub>2</sub> arteriografie může detekovat arteriální extravazaci v případech, kdy je rutinní angiografie nejasná nebo negativní. Angiogramy s použitím CO<sub>2</sub> nemohou poskytnout detailní vaskulární anatomii.

**Klíčová slova:** kontrastní látka, oxid uhličitý (CO<sub>2</sub>), digitální subtrakční angiografie, gastrointestinální krvácení

The detection and localization of acute massive gastrointestinal bleeding is notoriously difficult. Catheterization angiography is one of the steps in the diagnosis of and therapy for gastrointestinal bleeding among endoscopy (2), scintigraphy (1), helical contrast enhanced CT (5) and potentially MR (6).

Presently recognized and documented causes for failure to reveal gastrointestinal bleeding by angiography include: 1. Bleeding at a rate too slow to demonstrate by angiography (i.e. less than 0.5 mL/min.) (12); 2. Variceal bleeding in portal hypertension; 3. Technical problems, including injection into the wrong artery, non-selective injection, inadequate injection rate or volume, and failure to include the bleeding site on the angiographic field; 4. Permanent or temporary cessation of bleeding (16).

Carbon dioxide (CO<sub>2</sub>) has been shown to be a safe intra-arterial contrast agent (8). Its very low viscosity enables it to pass through the tiny defects, and once in the extravascular space the gas expands, thus maximizing the amount of extravasated contrast agent at the site of leakage (7,9).

On the other hand the probability of detection of extravasated iodinated contrast medium (ICM) can be potentially lowered by its high viscosity and dilution by the blood (7).

The purpose of our study was to compare the diagnostic efficacy of CO<sub>2</sub> and ICM in the detection of acute massive arterial haemorrhage.

## Materials and methods

### Patients

Over a 24-month period, 23 patients were referred for angiography to detect arterial haemorrhage. All included patients presented with a rapidly decreasing haematocrit, tachycardia and hypotension when continuous blood replacement was prevented. There were 14 patients with upper gastrointestinal bleeding, 7 patients with lower gastrointestinal bleeding and 2 patients with acute necrotizing pancreatitis. Five of these patients had previously undergone abdominal surgery (partial gastrectomy, ligation of the gastroduodenal artery, pancreatic necrectomy). Four patients had had repeated angiograms to detect the site of bleeding.

Except 2 patients, all had previously undergone gastrointestinal endoscopy (gastroscopy or colonos-

copy). Three patients had previously undergone scintigraphic evaluation.

### Angiography technique

All referred patients underwent routine angiogram starting with the superior mesenteric injection (50 mL of non-diluted low osmolal ICM) followed either by the coeliac trunk injection (40 mL of the same ICM), or inferior mesenteric injection (7 - 15 mL of the ICM). The images were performed using 1024 x 1024 digital subtraction angiography (DSA) and 40 cm image intensifier. Two injections with different centration of image intensifier were required in both the superior and inferior mesenteric injections.

The CO<sub>2</sub> angiogram was performed only in patients when standard ICM angiography was undetermined or negative. The CO<sub>2</sub> injection was performed using the same catheter and with the same centration as with the previous ICM injection. The 60 mL syringe was filled from the CO<sub>2</sub> reservoir through a sterile connecting tube and using a pressure reduction gauge.

The syringe was filled under pressure of the CO<sub>2</sub>. Any aspiration had to be avoided to rule out any inadvertent contamination by the room air. Then the 60 mL syringe with CO<sub>2</sub> was immediately attached to the hub of the diagnostic catheter. The flush saline or blood in the catheter was purged by slow and slight increasing of the pressure in the syringe. This small pre-injection of CO<sub>2</sub> was necessary to avoid explosive CO<sub>2</sub> delivery. This could be felt as a sudden decrease of the syringe cylinder resistance and seen by observing the small bubble of gas escaping from the catheter tip under fluoroscopy.

The volume of CO<sub>2</sub> injected varied between 30 to 60 mL. The DSA with the same matrix as in the ICM angiography was used with filming at 3 images per second and single frame mask without stacking of images.

Findings of extravasation or non-bleeding vascular abnormalities were considered as a diagnostic study.

### Results

There were 8 (30.8 %) positive angiograms out of 26 angiograms in 23 patients performed with the ICM. There were 3 (11.5 %) additional positive studies among 18 (69.2 %) negative ICM angiograms when the injection was performed using CO<sub>2</sub>. The proportion of negative angiograms decreased from 69.2 % to 57.7 % by using CO<sub>2</sub> supplementary studies. There were no complications observed using CO<sub>2</sub>.



**Fig. 1**  
A 57-year-old male with acute necrotizing pancreatitis. He had undergone surgically created communication of the pancreatic pseudocyst into the stomach 3 days ago. He was referred for visceral angiogram to reveal the source of acute upper gastrointestinal bleeding. The patient was hypotensive with a heart rate of 150/min. The coeliac trunk angiogram revealed no extravasation.



**Fig. 2**  
The same patient as seen in Fig. 1. Selective injection of CO<sub>2</sub> into the splenic artery with reflux into the left gastric artery - the early phase.



**Fig. 3**  
The same patient as seen in Figs. 1-2. Selective injection of CO<sub>2</sub> into the splenic artery with reflux into the left gastric artery demonstrated CO<sub>2</sub> extravasation (arrows) - the late phase.



**Fig. 4**  
The same patient as seen in Figs. 1-3. The selective left gastric arteriogram did not show any extravasation.

### Discussion

CO<sub>2</sub> as a negative contrast medium provides less contrast studies than the ICM and therefore use of a high resolution (i.e. matrix 1024 x 1024 pixels) DSA is necessary. With the advent of DSA in angiogra-

phy, CO<sub>2</sub> was utilized to decrease the ICM load, especially in patients with poor renal functions to avoid nephrotoxicity of the higher dose of the ICM. Complete elimination of CO<sub>2</sub> occurs after one passage through the pulmonary circulation, permitting the

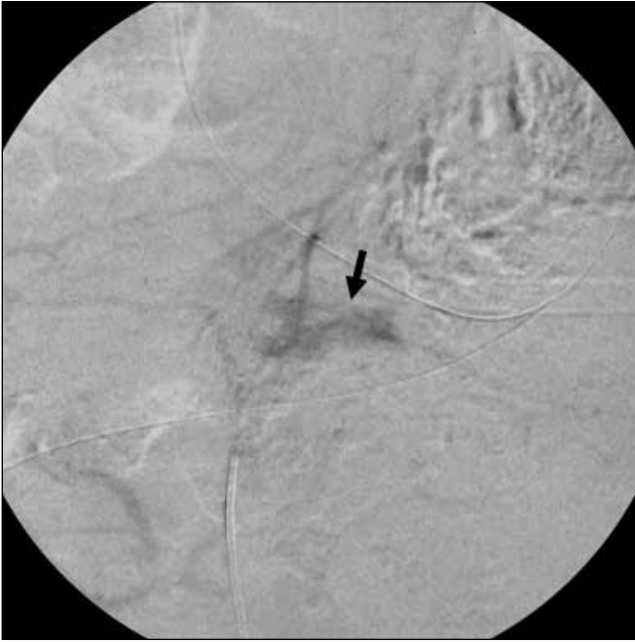


Fig. 5  
The same patient as seen in Figs. 1-4. Selective left gastric arteriogram. The extravasation was confirmed only on selective injection of CO<sub>2</sub> (arrow).



Fig. 6  
The same patient as seen in Figs. 1-5. Embolization with gelatine foam pieces was carried out through the diagnostic catheter (arrow).

injection of an unlimited number of low volume injections (7).

On the other hand CO<sub>2</sub> angiography is technically more demanding. The gas is compressible and its injection requires several technical details. The technique, which we have described, seems to be simple and safe since it avoids potential contamination with room air (3), direct inadvertent connection with the high-pressure CO<sub>2</sub> tank and small pre-injection avoids explosive delivery of the CO<sub>2</sub>.

The CO<sub>2</sub> has poorer contrast - noise ratio and extravasation can be missed due to bowel peristalsis artefacts on DSA. Especially patients who have previously undergone endoscopy are quite difficult to evaluate. The administration of drugs reducing peristalsis (butylscopolamin 20 mg i.v. or glucagon 0.2 - 0.5 mg i.v.) may be helpful. In some cases using a compression paddle to displace bowels filled with air is also recommended (18). We found it useful to perform the study during apnoea when the patient is intubated.

The reported complications (17) due to CO<sub>2</sub> injection such as abdominal pain, the urge to defecate or nausea which occur during the procedure are difficult to distinguish from clinical signs of gastrointestinal bleeding in our series of patients. We also did not observe any signs of transient mesenteric ischaemia as described previously elsewhere (17).

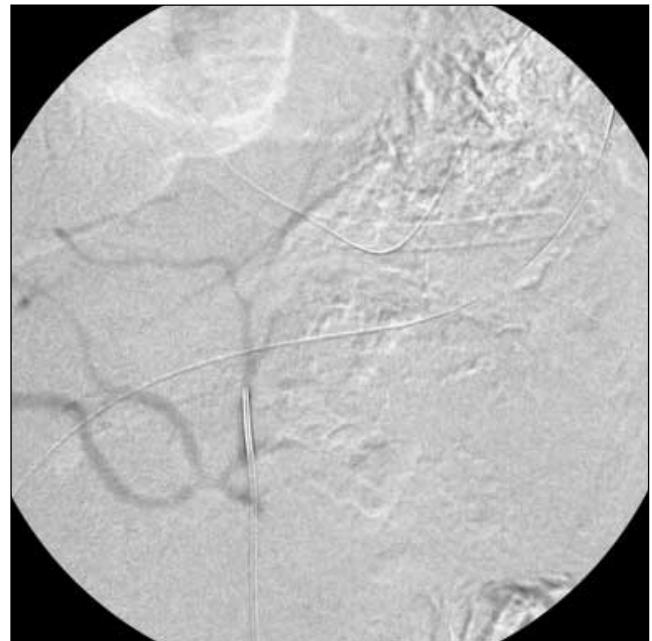


Fig. 7  
The same patient as seen in Figs. 1-6. Completion CO<sub>2</sub> angiogram confirmed no extravasation.

There are two studies on CO<sub>2</sub> in detection of extravasation in literature. Textor (19) found 26.6 % additional extravasations documented out of 15 patients and Sandhu (15) in a series of 15 patients did not find CO<sub>2</sub> better than ICM.

In our series, CO<sub>2</sub> angiogram revealed additional extravasation in 11.5 % and since acute massive gastrointestinal bleeding is a life threatening scenario, we strongly suggest use of CO<sub>2</sub> angiogram as a complementary study to routine ICM study in detection of arterial extravasation. CO<sub>2</sub> does not provide sufficient enough contrast to use without the ICM study, since detailed arterial morphological changes would be missed (11).

In comparison to provocative bleeding studies with intra-arterial infusion of tolazoline, heparin or tissue plasminogen activator (10,13,14), CO<sub>2</sub> angiography seems to be safer. Comparison of these techniques will require further research. However, the indications as well as the limitations of visceral angiography must be well understood by both the angiographer and the referring clinician.

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