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Complications of Digital Intravenous Angiography: Experience in 2488 Cervicocranial Examinations

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All complications were recorded from the initial 2488 cases studied with digital intravenous angiography (DIVA) at New York University Medical Center. Mechanisms of producing these reactions were categorized into procedure-related, contrast-medium-related, or disease-related. The complications included extravasation of contrast material into the arm (11 patients) and mediastinum (two), acute pulmonary edema (four), hypotension (23), thrombophlebitis (two), and grand mal seizure (one). Recommendations are made that would allow DIVA to be performed more safely.

In a relatively short period of time digital intravenous angiography (DIVA) has become a prime radiologic method for the study of the intracranial, extracranial [1–7], and peripheral vasculature [8–15]. It is our purpose to report on the complications of DIVA in the first 2488 cases studied at our institution. We have attempted to categorize these complications as procedure-related, contrast-medium-related, or disease-related.

Materials and Methods

A 65 cm, straight Teflon catheter (supplied by Universal Medical Instruments, Ballston Spa, NY) having four, six, or 10 side holes was introduced into an antecubital vein and advanced to the superior vena cava in 2275 patients. For about the first 500 cases 40 ml of Renografin 76 (Squibb) contrast material was injected per series at a rate of 20 ml/sec. Thereafter, an injection rate of 15 ml/sec was used.

In 213 cases an 8-inch-long (20 cm), straight, single-end-hole Teflon catheter (Universal Medical Instruments) was placed into the basilic or cephalic vein. The size of the peripheral vein was estimated by visualization of a test injection. If the vein was large in comparison with the inserted catheter an injection rate of 14 ml/sec was used for a total volume of 40 ml of 76% contrast medium. If the vein was small but still larger than the introduced catheter, the injection rate was decreased to 10 ml/sec. If the vein was smaller than the introduced short catheter no injection was made.

When the short catheter was used, 25 ml of saline was layered in the injector syringe above the contrast medium for each bolus injection. When a long catheter was used, imaging was performed with attention to the initial frames during the injection to document the presence or absence of catheter recoil.

Results

Eleven (5.2%) of 213 examinations performed with the short catheter resulted in contrast-medium extravasation in the arm (fig. 1).

Two patients studied with a long catheter in the superior vena cava or right atrium developed mediastinal extravasation. One catheter had four side holes, the other six (fig. 2). In one case in which there was placement of a 10-side-hole catheter in the right atrium, right atrial extravasation occurred with pericardial effusion documented by chest films (fig. 3). The incidence of mediastinal contrast-

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Fig. 1.—Extravasation of contrast material using 8 inch (20 cm), 5.5 French, single-end-hole catheter. Catheter was introduced into basilic vein. Under fluoroscopic control, test injection showed vein to be of moderate size, and catheter tip was positioned away from any tributary or valve. Subsequently injected contrast media extravasated within arm. Injection factors were 40 ml of 76% contrast media with 25 ml of saline layered within injector syringe, injected at 14 ml/sec, 300 psi (21.1 kg/cm^2), and 0.3 linear rate rise.

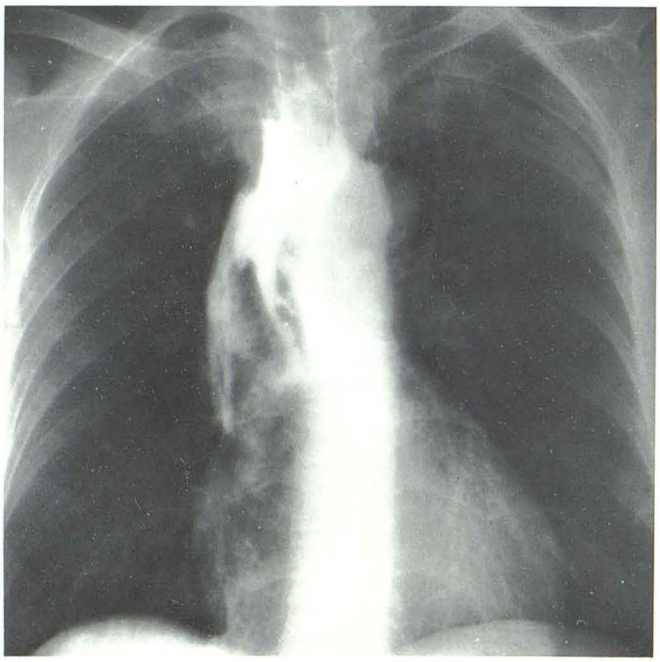


Fig. 2.—Mediastinal extravasation of contrast medium. Anteroposterior chest film demonstrates contrast medium outlining walls of superior vena cava. A 5.5 French Teflon catheter was positioned in midportion of superior vena cava. Catheter had four side holes. Initial injection was uneventful. Subsequent injection produced acute chest pain and hypotension for 30 min. Injection factors were 40 ml of 76% contrast medium injected at 20 ml/sec, 450 psi (31.6 kg/cm^2), and no linear rate rise.

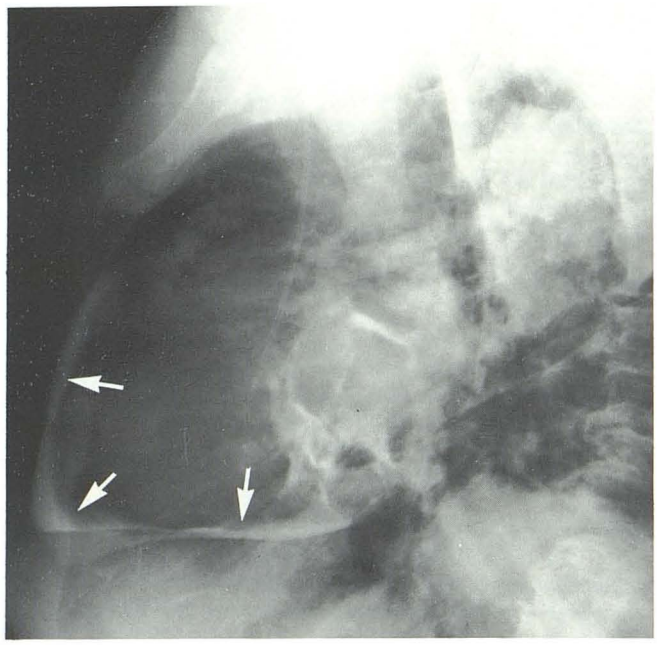


Fig. 3.—Right atrial extravasation of contrast medium. Lateral chest film demonstrates right atrial extravasation and contrast-medium pericardial effusion. The 5.5 French Teflon straight catheter was positioned within right atrium. Initial injection produced neck pain, which prompted chest films. Note is made of contrast-medium pericardial effusion (*arrows*). Low position of catheter is faintly observed. It is presumed that recoil of catheter occurred during initial part of injection with repositioning of catheter tip within coronary sinus, thereby resulting in atrial extravasation and pericardial effusion.

medium extravasation with a long (superior vena cava–right atrial catheter) was 0.13%.

Both patients with mediastinal extravasation developed immediate chest pain and hypotension that lasted for about 30 min. No further sequelae occurred, although both patients were watched closely for 24 hr afterward.

The one patient with right atrial extravasation and pericardial effusion developed neck pain after the initial injection of contrast material, also lasting for about 30 min. No alteration of vital signs occurred. A cardiac echogram was obtained that showed a small pericardial effusion initially. Repeat examination 24 hr later failed to show any pericardial effusion. No electrocardiographic (ECG) changes occurred in the patient with right atrial extravasation, although ECG changes of a pericardial irritation developed in one patient with mediastinal extravasation. Of the 11 patients who had contrast-medium extravasation in the arm from use of the short catheter, nine experienced local pain lasting 30 min to 72 hr beginning immediately after injection. No other sequelae developed in these 11 patients.

Other minor complications associated with the intravenous technique included four catheter introductions into the brachial artery, two patients who developed a focal cellulitis at the puncture site, and 13 failed examinations in which an antecubital venous puncture was unsuccessful. Twelve of these patients underwent a femoral venous puncture.

Of the contrast-medium-related complications, four patients in our series developed acute pulmonary edema (fig. 4). All four had a total dose of 160 ml of 76% contrast medium. All

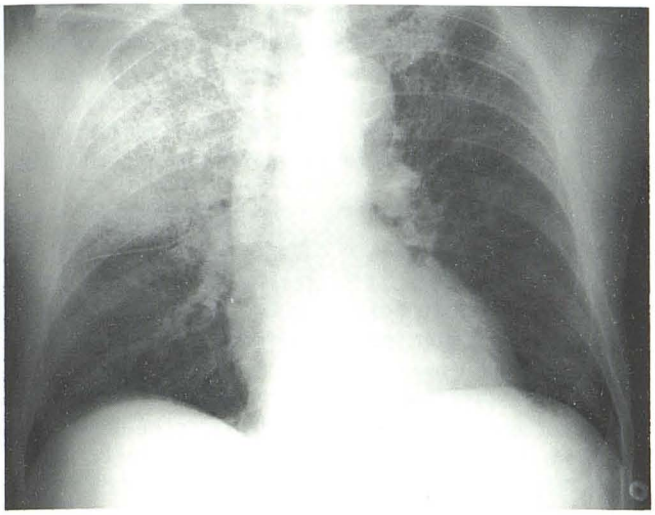


Fig. 4.—Acute pulmonary edema in patient with known cardiac disease. Four separate projections were accomplished with administration of total volume of 160 ml of 76% contrast medium. About 3 min after completion of study patient complained of shortness of breath and cough. Forthy sputum was being expectorated. Chest films immediately documented bilateral upper-lobe infiltrates, more so in right upper lobe. Chest film 1 day before was normal.

four patients also had a cardiac history: three had myocardial infarctions, and one had prior congestive failure. All four patients had prolongation of circulation time as recorded by the digital vascular examination.

Hypotension occurred in 23 patients. In 22 of these patients the hypotension was induced by sitting up at the end of the study, and it cleared quickly once the patient was replaced in the supine position. One patient suffered a vasomotor collapse, in which the blood pressure had to be supported by vasopressive drugs for 15 hr.

Two patients developed thrombophlebitis of the arm after DIVA using a short catheter. One patient developed a grand mal seizure 6 hr after the DIVA study.

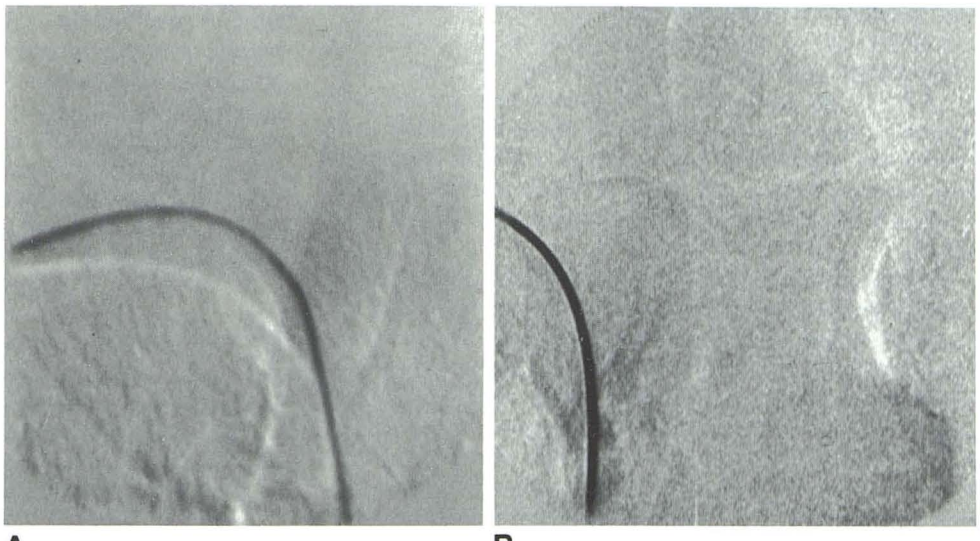
Early in our investigation, two patients underwent a digital vascular study having a normal BUN and creatinine. These two patients, one having a long history of hypertension and the second being a known adult-onset diabetic, underwent the study and serendipitously had a repeat BUN and creatinine drawn 24 hr after DIVA. Elevation of these functions were found, and they returned to normal in 2 and 3 days, respectively [16, 17]. No oliguria or anuria occurred in either of these patients or in any patient studied in our series.

Discussion

Procedure-Related Complications

Contrast-medium extravasation within the arm with the use of a short, single-end-hole catheter occurred in our series at an incidence of 5.2%. All insertions of the catheter were evaluated with a test injection to determine the size of the vein and to avoid placing the catheter tip near a tributary of the vein or a valve of the vein. Injection rates were adjusted relative to vessel size. Even with these precautions, contrast-medium extravasation occurred, probably on the basis of whipping of the catheter tip, which presumably perforates the relatively thin vein wall. The incidence of contrast-media extravasation in the arm has led us to perform most of our DIVA studies with a long catheter placed into the superior vena cava.

With the long catheter the incidence of contrast-medium extravasation was 0.13%. We have documented by observation of the initial digitized image that marked recoil occurs when four- or six-side-hole catheters are used (fig. 5A). We have seen a catheter initially placed in the superior vena cava relodge into the azygos vein after injection. We believe that the mechanism for contrast-medium extravasation into the mediastinum with the use of a long catheter is recoil of the catheter during the injection and its relodging into a tributary of the superior vena cava such as the azygos vein. Catheter recoil greatly diminishes with the use of a 10-side-hole catheter (fig. 5B). Recoil is also reduced by using injection rates of 15 ml/sec or less, and, if available, setting a linear rate rise on the power injector. With these precautions there is virtually



A B

Fig. 5.—Recoil phenomenon of catheters. **A**, Recoil of catheter is demonstrated by analysis of first two images from DIVA series. First image, after radiographic mask, is used as new subtraction mask and shows catheter without contrast material in white combined with second image of series showing contrast medium within catheter as black. Note upward mobility of catheter during 1 sec interval of initial part of injection. Catheter was straight, 65 cm, 5.5 French Teflon catheter with six side holes. **B**, Catheter was 5.5 French, 65 cm, straight catheter with 10 side holes. Again, first digital image is used as mask and second image is during contrast medium injection. With this catheter, minimal recoil is documented with no separation of catheter images on injection of contrast medium.

no recoil of the catheter, except in the unusual instance of a patient with elevated central venous pressure.

Ideally, the catheter tip should be placed low in the superior vena cava, just above its junction with the right atrium. This is well away from the caval tributaries, most of which arise from the upper part of the cava. Placement in the right atrium is to be avoided; we believe that our case of atrial extravasation and pericardial effusion, which occurred with the catheter tip in the atrium, was from recoil into the coronary sinus.

We have avoided the use of a pigtail catheter because of difficulty in advancing this catheter to the superior vena cava as well as the inherent pain that occurs both on introduction and removal, even when the catheter is passed or withdrawn over a guide wire.

Both patients with mediastinal extravasation developed immediate chest pain and hypotension that lasted for about 30 min. No further sequelae occurred, although both patients were watched closely for 24 hr. Since we have resorted to a 10-side-hole and single-end-hole, straight Teflon catheter; dropped our injection rate to 15 ml/sec; and used a 0.3 linear rate rise for more than 1700 cases, no mediastinal extravasation has occurred [18, 19].

Contrast-Medium- and Disease-Related Complications

Four patients in our series developed acute pulmonary edema [20, 21]. All four patients were given a total contrast dose of 160 ml of 76% contrast medium. All four patients had a cardiac history and had documented prolongation of circulation time as recorded during the digital vascular examination. We have eliminated this complication by obtaining a cardiac history from all patients that alerts us to evaluate the transit time of contrast medium from the superior vena cava to the carotid bifurcations. Circulation time is assessed via the digital vascular imager by adding the number of seconds of changer delay set on the automatic injector to the number of nonangiographic images recorded before initial visualization of contrast medium at the region of interest, the carotid bifurcations. Empirically normal cardiac-function patients have a superior vena cava–carotid bifurcation transient time of 4–6 sec. The four patients who developed acute pulmonary edema at the completion of the digital vascular study all had circulation times greater than 10 sec, with one having a circulation time of 17 sec. If the circulation time is prolonged to greater than 10 sec, limitation of total dose of contrast material is warranted. We recommend that a limited study be performed with no more than a total dose of 80 ml of 76% contrast medium in any patient having a circulation time greater than 10 sec.

Hypotension occurred in 23 patients undergoing a digital vascular examination. In 22 patients the hypotension was on the basis of peripheral vasodilatation secondary to the administered contrast medium and was clinically induced by elevation of the patient to the sitting position. The hypotension cleared quickly once the patient was replaced in the supine position [22, 23]. In one patient hypotension occurred without an increase of the pulse rate and was unresponsive to the initial administration of atropine or epinephrine. In this patient blood pressure had to be supported by vasopressive drugs for about 15 hr. This form of hypotension (vasomotor collapse) is in all probability a hypersensitivity response to contrast material [24]. No allergic history was obtained from this patient nor did she have any risk factors such as asthma or eczema to predict the possibility of a reaction to administered contrast material.

Two patients developed thrombophlebitis of the arm 1 and 3 days after the use of a short catheter [20, 25]. We assume that this was secondary to the hypertonicity of contrast media irritating the endothelium of the injected vein rather than injury caused by the catheter, although it may have been a contributing factor.

One patient developed a grand mal seizure 6 hr after the digital vascular examination with a subsequent negative computed tomographic (CT) scan of the brain. The etiology of this seizure is unknown, but may have been secondary to the administered contrast medium and to its inherent neurotoxicity [26].

As a precaution we have required a BUN and creatinine result on all patients before an intravenous angiogram. We limit the total amount of contrast medium if the creatinine is 2–3 mg/dl and will not obtain an intravenous angiogram if the creatinine is greater than 3 mg/dl. Patients with overt renal failure are best examined by arteriography, where lower doses and volumes of contrast material may be administered. Following this protocol no clinically overt renal failure has occurred.

DIVA is a relatively safe procedure. Most complications that have occurred in performance of this examination have been mild, short-lived, and possibly avoidable. Our recommendations for performing safe DIVA is to use a recoilless catheter placed in the superior vena cava proximal to the right atrium with administration of contrast medium at an injection rate of no more than 15 ml/sec and, if available, with a linear rate rise on the injector. Pertinent patient history should be obtained on all patients before injecting relatively large doses of contrast material. Orthostatic hypotension may be avoided by delaying elevation of the patient to an upright position for 5–10 min after completion of the examination and by avoiding rapid, sequential injections of large volumes of contrast material. In any high-risk patient such as those with a cardiac history, diabetes, or renal dysfunction, limitation of total dose of contrast material is warranted, particularly if these patients are studied as outpatients. Even if there is no known cardiac history, circulation time should be monitored in all patients, with reduction of total dose of contrast material if the circulation time is greater than 10 sec. Following these recommendations, DIVA may approach the safety of other noninvasive radiologic methods.

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