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AJNR Am J Neuroradiol 1989, 10 (5) 1061-1064
http://www.ajnr.org/content/10/5/1061

Cerebral Distribution of Contrast Medium During Slow Intracarotid Infusion

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A prospective study was performed to evaluate in vivo the uniformity of cerebral distribution of iodinated contrast medium during slow intraarterial injection at rates used for chemotherapy installation in the internal carotid artery. We evaluated seven patients with primary intracranial neoplasms with routine film-screen angiography and with digital angiography during slow infusion. In six internal carotid artery injections the distribution of contrast material was identical during the late arterial phase of routine angiography and the digital study. In three vertebral artery injections the opacification during the slow infusion was inadequate to make meaningful comparison.

Our results indicate that solutions infused into the internal carotid artery at rates as low as 0.25 ml/sec are distributed well throughout the carotid territory opacified during the late arterial phase of film-screen angiography.

***AJNR* 10:1061–1064, September/October 1989**

Intraarterial chemotherapy for the treatment of primary intracranial neoplasms is being used with decreased systemic toxicity [1–3]. The agent most commonly used is carmustine (BCNU). This is usually administered at slow injection rates with the catheter in the cervical internal carotid artery or vertebral artery. Complications have been reported that may be related to incomplete mixing of the chemotherapeutic agent with blood in the carotid artery [2, 4, 5].

The objective of this study is to evaluate the distribution characteristics of infusate during slow intraarterial injection.

Materials and Methods

Between July 1986 and March 1987 we evaluated seven patients with primary supratentorial intracranial neoplasms in conjunction with intraarterial BCNU chemotherapy. Four of the patients had tumors supplied by one internal carotid artery, one patient had a tumor supplied solely by the posterior circulation, and two had tumors with mixed supply from both an internal carotid artery and the posterior circulation. The patients were evaluated after obtaining informed consent.

The patients underwent transfemoral catheterization with a 5-French end-hole (JB2) catheter. The catheter was placed in either the cervical internal carotid artery or cervical segment of a vertebral artery. Standard film-screen angiography was performed after injection of an average of 6.0 ml iothalamate meglumine (Conray 60) over 1 sec in the vertebral artery or 8.0 ml Conray 60 over 1 sec in the internal carotid artery. Biplane filming was performed for each injection. Digital imaging was then performed in the lateral and/or anteroposterior projection during slow infusion of Conray 60 with a Harvard infusion pump at the rates used for chemotherapy installation. The catheter was in the same position as during the routine angiographic examination. Infusion rates of Conray 60 were 0.125 ml/sec for vertebral imaging and 0.25 ml/sec (five patients) or 0.5 ml/sec (one patient) for internal carotid imaging. Subtraction films of the film-screen run in early arterial phase and late arterial phase were compared with the digital run during slow infusion to evaluate for differences in distribution of contrast material.

Received December 8, 1988; revision requested January 12, 1989; revision received February 8, 1989; accepted February 20, 1989.

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0195-6108/89/1005–1061

Results

The distribution of contrast agent during the slow intraarterial infusion paralleled the distribution during the late arterial phase after standard film-screen angiographic injection rates in all six internal carotid examinations. The arterial branches opacified were identical (Fig. 1). The early arterial phase of the film-screen angiogram after standard angiographic injection rates demonstrated transient filling of the contralateral internal carotid branches in four of the patients that was not demonstrated on either the late arterial phase after standard angiographic injection rates or on the slow infusion (Fig. 1). In one of these patients there was also transient filling of the ipsilateral anterior and posterior cerebral arteries (Fig. 2). The correlation between distribution of contrast material during the slow intraarterial infusion and the late arterial phase after standard film-screen angiographic injection rates was also demonstrated in the patient with the most vascular tumor (Fig. 3).

With vertebral artery infusions, the opacification in two patients was faint during slow infusion, with only the injected vertebral artery and the basilar artery identified definitely. On lateral views there was also opacification of another vessel, which may have been either the posterior cerebral artery or the superior cerebellar artery. This could not be identified on the anteroposterior view. In one patient, the opacification during slow vertebral artery infusion was so poor that no comparison could be made to the distribution at standard film-screen angiographic injection rates.

Discussion

Studies have demonstrated incomplete mixing of effluent from intracarotid catheters both in vitro and in vivo (Rhesus

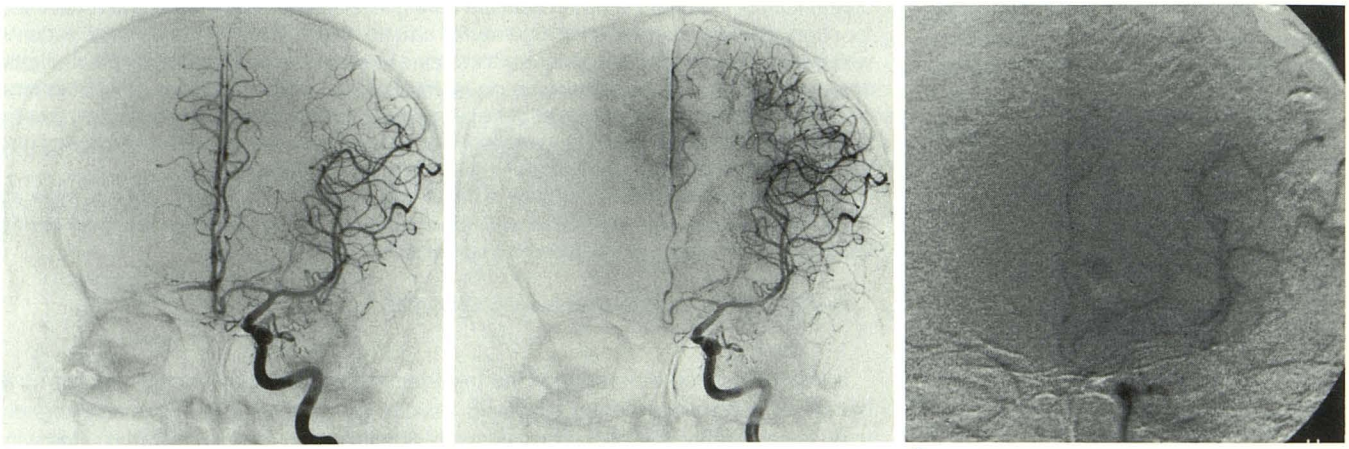

Fig. 1.—Case 1.
Early arterial phase (*A*) demonstrates transient opacification of contralateral anterior cerebral artery, which is not present on late arterial phase (*B*) or during slow infusion (*C*).

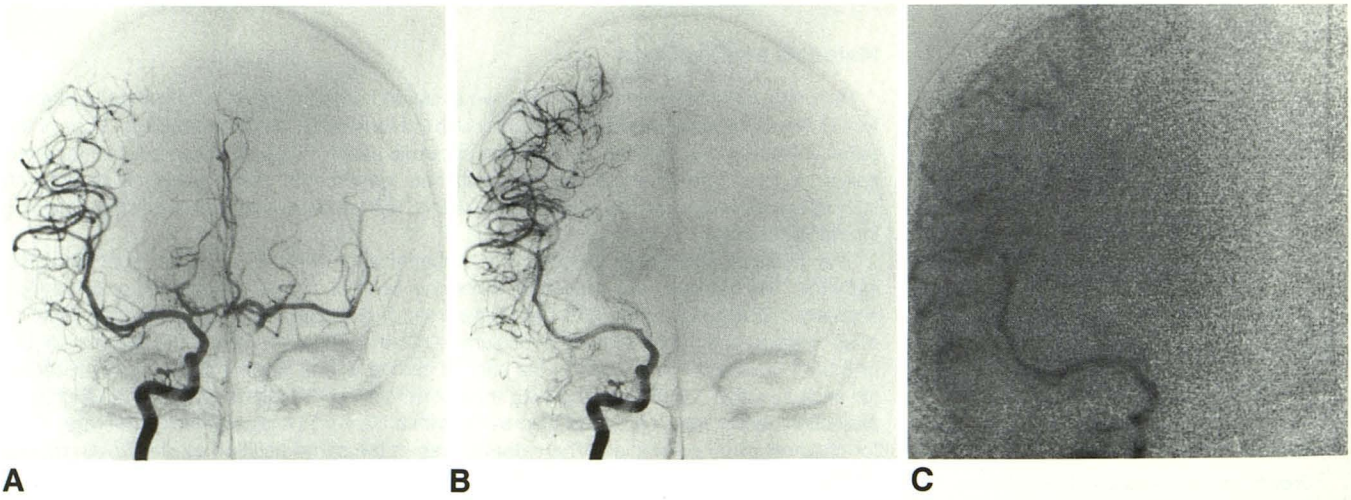

Fig. 2.—Case 2.
Early arterial phase (*A*) demonstrates transient opacification of contralateral anterior, middle, and posterior cerebral arteries, as well as ipsilateral anterior and posterior cerebral arteries. Opacification is not present on late arterial phase (*B*) or during slow infusion (*C*).

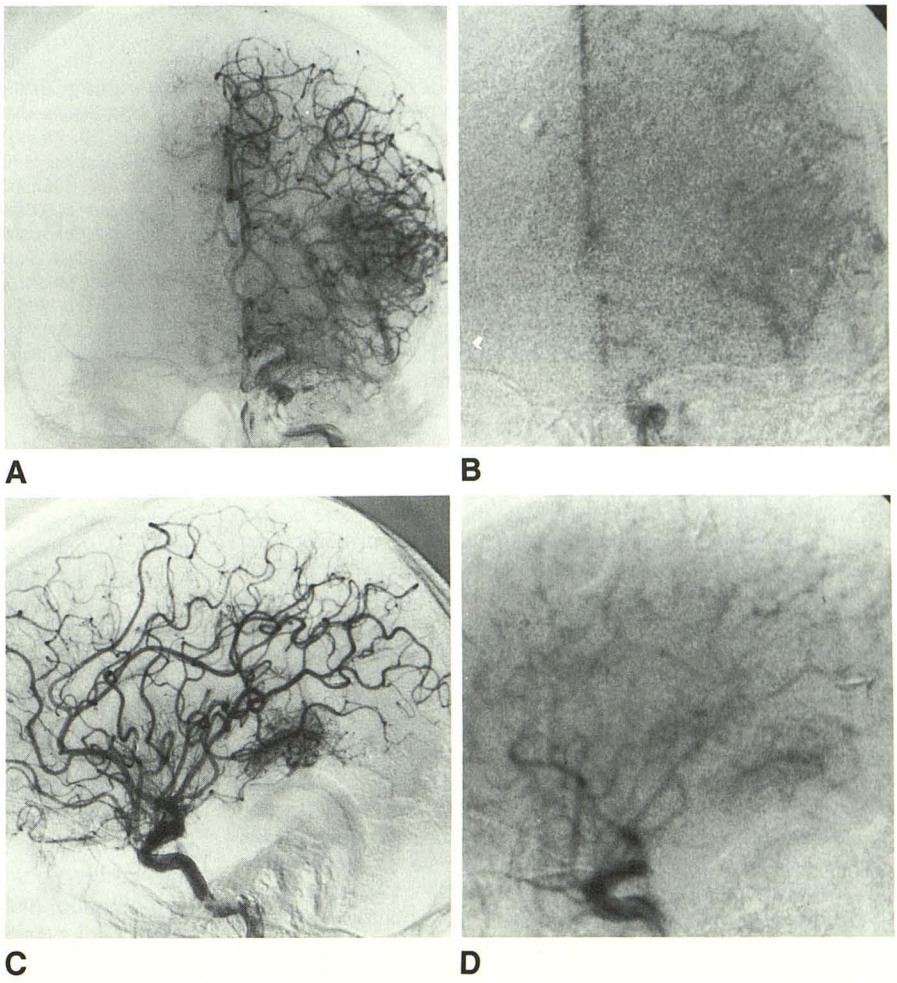

Fig. 3.—Case 3.
Patient with vascular tumor. Late arterial phase, anteroposterior projection (*A*); slow infusion, anteroposterior projection (*B*); late arterial phase, lateral projection (*C*); and slow infusion, lateral projection (*D*).

monkeys) during slow intraarterial infusion [6, 7]. These studies have demonstrated that drug streaming from the catheter tip is the main cause of the incomplete mixing and the subsequent variable distribution within the perfused carotid territory. Focal toxicity in the CNS after intraarterial chemotherapy in both animals and humans was reported by French et al. [4], who noted that inability to control the intracranial distribution of chemotherapeutic agents would limit the use of this technique. Complications reported from a study of 36 patients [2] include nine cases of unilateral ocular toxicity (retinal artery narrowing, retinal hemorrhages, and nerve fiber layer infarcts) and seven cases of unilateral low-density white matter abnormalities. One possibility is that incomplete mixing resulting from streaming contributes to focal toxicity.

The in vivo (Rhesus monkey) study of Blacklock et al. [7] demonstrated marked nonuniformity at infusion rates of 0.2–0.4 ml/min with achievement of uniformity at an infusion rate of 4.0 ml/min. The in vitro study by Lutz et al. [6] showed prominent streaming at 2.0 ml/min, which improved at infusion rates of 24.0 ml/min and became almost homogeneous at an infusion rate of 17.0 ml/min with the use of a jet-controlled catheter developed in their laboratory. French et al. [4] used an injection rate of 2.0 ml/min and Greenberg et al. [2] employed injection rates between 6.7 and 10.0 ml/min. Our studies were performed at an injection rate of 15.0–30.0 ml/min (0.25–0.5 ml/sec) with no evidence of streaming or nonuniform mixing at either rate. We believe that for a 5-French end-hole catheter placed with its tip in the cervical internal carotid artery, an injection rate of 15.0 ml/min is sufficient to prevent streaming.

We were unable to obtain satisfactory opacification during slow infusion in the vertebral artery to make meaningful comparison with the routine angiogram. This suggests that our infusion rate (0.125 ml/sec) in the vertebral artery may have represented a smaller percentage of the flow in that vessel than the infusion rate in the internal carotid artery (0.25–0.5 ml/sec) represented. Alternatively, the catheter may have been partially occluding the lumen of the vertebral artery in which it was placed, leading to an increased proportion of flow from the contralateral vertebral artery.

Our results indicate that digital imaging can be useful for evaluating vascular distributions, particularly in the carotid territory. This may serve two purposes. First, it may be useful for evaluating the distribution of infused solutions through a variety of infusion systems at rates as low 0.25 ml/sec. Second, it may be useful for evaluating the distribution from

a vessel in the physiological state. Our data indicate that rapid high-pressure infusions are likely to transiently distribute into vascular territories not normally supplied, but slow infusions are likely to show a pattern of distribution similar to the normal pattern of blood flowing in the infused artery.

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