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# Use of the Delayed Mask for Improved Demonstration of Aneurysms on Intraarterial DSA

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**PURPOSE:** We retrospectively explored the use of the delayed mask technique for intraarterial digital subtraction angiography (IADSA) to demonstrate the anatomy of aneurysm necks. **METHODS:** The delayed mask technique was utilized in 22 patients who had craniotomies for aneurysms demonstrated at angiography. The operative notes were compared to the angiographic findings of both the traditionally masked IADSA and the delayed mask IADSA. In addition, an in vitro model was constructed to examine the relationship between the size of the aneurysm neck and the ability to indirectly define its anatomy by demonstrating the flow jet. **RESULTS:** In 12 of 22 cases, the delayed mask technique demonstrated a systolic jet that was not demonstrated by traditional subtraction techniques. In nine of 12 cases, the delayed mask technique gave more specific information regarding the size, location, and orientation of the aneurysm neck. **CONCLUSION:** The delayed mask technique can add important information regarding the anatomy of aneurysm without adding time or risk to the procedure.

**Index terms:** Angiography, technique; Aneurysm, arteriovenous; Models, anatomic

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The efficacy of intraarterial digital subtraction angiography (IADSA) in evaluating patients with suspected intracranial aneurysms has been previously demonstrated (1). However, the image/data reconstruction and manipulation capabilities of IADSA have not been fully exploited to determine aneurysm anatomy. Our goal was to study the utility of the delayed mask technique in assessing aneurysm anatomy. Specifically, we wanted to determine if the delayed mask technique improved detection of a systolic jet of contrast into the aneurysm, therefore indirectly determining the anatomy of the aneurysm neck. In addition, we wanted to correlate the imaging results with findings at surgery.

## Materials and Methods

Retrospective analysis of 22 aneurysm patients studied with IADSA over a 15-month period was done. All had undergone successful surgical clipping or had adequate anatomic assessment during the operative procedure for comparison with the angiographic findings.

All studies were performed by injecting into either the internal carotid artery or vertebral artery. The majority of studies were done on a Technicare Angiographic System using a 512 × 512 × 10 bit matrix. A few studies were performed on a Siemens angiographic system utilizing a 1024 × 1024 matrix. Filming was performed either at 3 or 4 frames per second. In a few cases filming was performed at 6 frames per second. Contrast material was Omnipaque 300 in all cases. The volume of the contrast injected was chosen by the angiographer based on the vessel size and varied between 3 and 6 mL per second, with totals varying between 4 and 8 mL per vessel.

The technique of delayed masking involves choosing a late frame in the run that ideally contains only the opacified aneurysm dome and using it as a mask to subtract earlier frames (Fig. 1). Since the aneurysms usually fill best during systole and empty best during diastole, there is a delayed washout in many cases, allowing such an image to be obtained either in the venous phase or after the venous phase is completed. There were usually several frames in the run showing the systolic jet. Because systole and diastole may occur several times within a given run, use of the delayed masks allows the visualization of the jet during several systoles as well as visualization of nearby branches not evident on all frames or any single frame.

In the 22 patients who were operated upon, the angiographic findings utilizing the traditional masking technique

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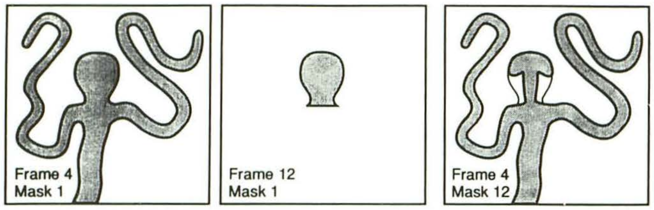



Fig. 1. Delayed masking technique.

The traditional masking technique would be to use a frame showing opacification of the blood vessels such as *frame 4* and an early mask containing only the osseous structures such as *mask 1* to display an image of the vascular structures only. The first image on the left above illustrates this technique with an aneurysm at the vessel bifurcation. The delayed masking technique chooses a mask which ideally contains only the opacified dome of the aneurysm. The center picture above shows the subtracted version of this mask, *frame 12*, with the osseous structures subtracted by utilizing mask 1. In actual practice the delayed masking technique is performed by using the same frame number with vascular opacification as in the traditional masking technique, in this case, *frame 4*. The delayed mask, in this case *frame 12*, is then used to subtract the dome of the aneurysm leaving the opacified neck. By using this technique, the precise location of the aneurysm neck can be judged.

and the delayed masked images were reviewed, compared, and correlated with the operative findings in the following manner: Three observers unfamiliar with this case material but trained and experienced in cerebral angiography independently reviewed the angiograms. First, they were randomly shown the traditionally masked, best view or views of each case and were asked to describe the neck of the aneurysm as to its size and location and to try to identify a jet. On a separate occasion, the same reviewers were shown the delayed mask studies and attempted to answer the same questions. The observers were shown hard copy original films that had been realigned for optimal subtraction and gray scale by the same operator on the same console. When at least two observers correctly identified a jet and the aneurysm origin, the study was scored as positive.

## Results

A systolic aneurysm jet was visualized in three/22 patients utilizing the traditional initial masking technique. The systolic jet was seen in 15/22 patients utilizing the delayed masking technique. There were 12/22 patients in which the systolic aneurysm jet was seen only utilizing the delayed masking technique and not utilizing the traditional initial masking technique. There were seven/22 patients where a systolic jet could not be demonstrated either by the delayed masking or the traditional masking technique.

Further review of the seven patients in whom a jet could not be demonstrated by either technique revealed that in all of these cases the greatest diameter of the aneurysm was equal to or smaller than the lumen of the parent vessel. This suggested that the size of the lumen of the aneurysm relative to that of the parent vessel was a determining factor in the presence of a demonstrable jet.

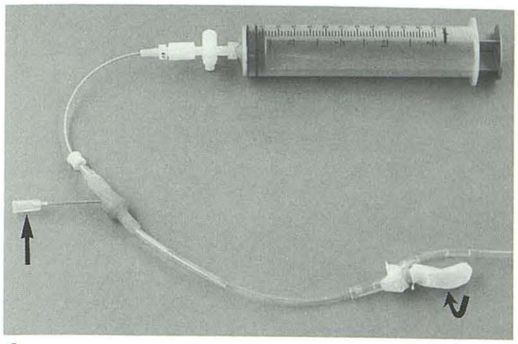
To test this hypothesis two simple models were constructed utilizing intravenous tubing to represent the parent blood vessel and the fingertip of a surgical glove to represent the aneurysm dome (Fig. 2). In one of these models, the "aneurysm" was constructed several times larger than the diameter of the tubing. In the other "aneurysm," the size of the dome was constructed to be approximately the lumen of the intravenous tubing. These models were filled with saline and injected with contrast at the same rate while digital acquisitions were performed. A jet was demonstrated in the model with the "giant aneurysm," not in the smaller "aneurysm." While drawing conclusions from biophysical models is hazardous, we feel this is of some interest (2).

The operative notes and surgical results were reviewed in the 12 cases where the delayed masking technique showed a jet but the traditional subtraction technique did not. In nine of these 12 cases, it was possible to give more specific information about the location and direction of the aneurysm neck as well as the size of the neck relative to the aneurysm (Table 1) or to be more precise about the location of neighboring blood vessels to the neck of the aneurysm. This information correlated with findings at surgery in all nine cases. In one of the 12 cases, delayed masking revealed that multiple aneurysms were present when the traditional subtraction technique suggested a multilobed aneurysm.

## Discussion

While recent techniques such as clip design, improved microscopes, anesthesia and spasm therapy have improved the outcome in aneurysm therapy, some aneurysms continue to present difficulties because of their size, shape, and position. In a recent large study (3), the most common reason for failed surgery was described as "clipping abandoned." This most often had to do with the inability to isolate the neck because it was hidden behind vital structures, it was too broad based to clip, or branches arose at or near the neck.

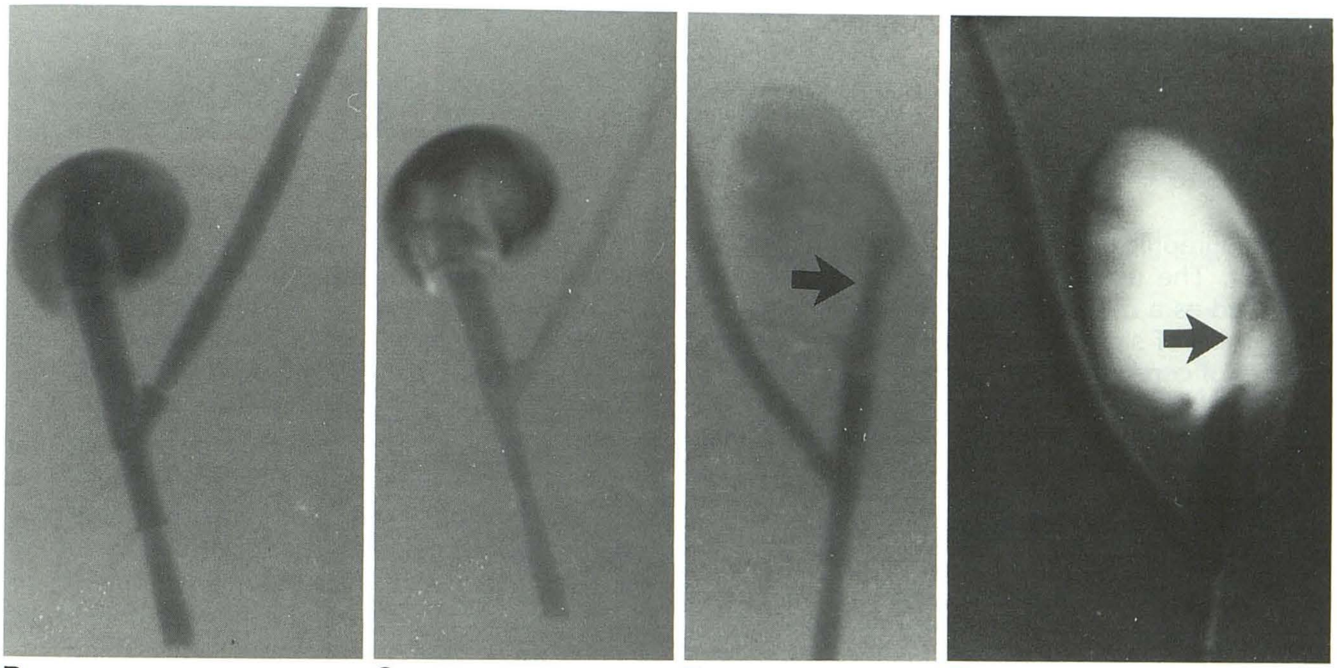
Neither the concept of sequential subtraction nor the usefulness of identifying the systolic jet



A

Fig. 2. In vitro model.

This model was constructed from intravenous tubing and utilized the cut fingertip of a surgical glove to illustrate the aneurysm (*curved arrow*). Normal saline was rapidly run through the needle (*straight arrow*). Contrast material was injected, as a bolus, into this stream. Filming was performed over the "aneurysm." *B* is an example of this in vitro technique and no definable aneurysm neck or jet effect seen. *C* is the same aneurysm filmed utilizing the delayed mask technique. Again, a well-defined neck or jet is not demonstrated. *D* is an example of this technique utilizing a relatively large "aneurysm" dome and the traditional mask technique. Note that the neck and jet of the aneurysm are better visualized when the aneurysm is large relative to the size of the neck (*arrow*). *E* is the same large aneurysm as seen in *D* filmed utilizing the delayed mask technique. Note that the jet from the inflow of contrast material is better seen utilizing the delayed mask technique (*arrow*) than the traditional type.

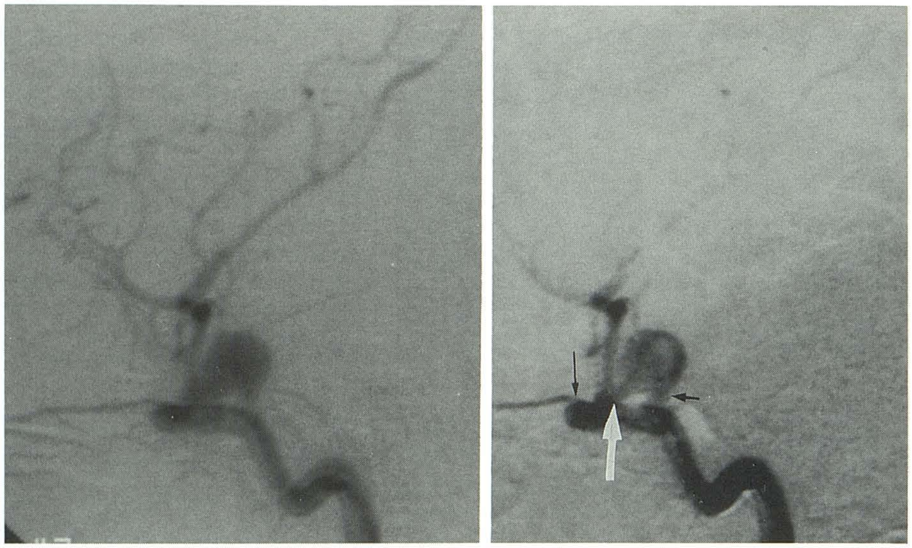


B C D E

TABLE 1: Additional data acquired using delayed mask

| Patient | Angio Findings | Delayed Mask: Additional Findings | Surgery Findings |
|---|---|---|---|
| 1 | 1-cm supraclinoid | Distal to ophthalmic | Distal to ophthalmic |
| 2 | Basilar tip aneurysm | Posterior cerebral origin | Posterior cerebral origin |
| 3 | 2-cm intracavernous aneurysm | Origin in proximal limb of siphon | Surgically exposed and trapped |
| 4 | Supraclinoid aneurysm | Origin opposite ophthalmic | Origin from posterior wall of supraclinoid carotid |
| 5 | Intracavernous aneurysm | Ophthalmic a aneurysm | Ophthalmic a aneurysm |
| 6 | Basilar tip aneurysm | Right posterior cerebral origin aneurysm | Right posterior cerebral origin aneurysm |
| 7 | Posterior cerebral artery giant aneurysm | 1 cm from basilar tip | 2 cm from basilar tip |
| 8 | Intracavernous giant aneurysm | Supraclinoid origin giant aneurysm | Supraclinoid origin |
| 9 | MCA aneurysm | Origin proximal to trifurcation | Proximal to trifurcation |

Note.—MCA, middle cerebral artery.



A B

Fig. 3. Supraclinoid aneurysm.

This is patient 4 from Table 1. The lateral view from the internal carotid artery injection (*A*) shows an aneurysm in the region of the intracavernous and supraclinoid portions of the internal carotid artery. It is not clear whether the origin is in the proximal loop of the cavernous carotid artery, at the genu of the intercavernous portion, immediately opposite the ophthalmic artery or in the supraclinoid carotid. *B* is the same injection utilizing frame 7 and mask 12. The origin of the aneurysm can now be clearly defined by virtue of the jet (*B, white arrow*). A small nipple can be seen posteriorly and inferior (*B, small black arrow*). On the traditional masking view, this might have been mistaken for the aneurysm neck. The origin of the ophthalmic artery is seen directly opposite to the origin of the aneurysm (*B, long arrow*).

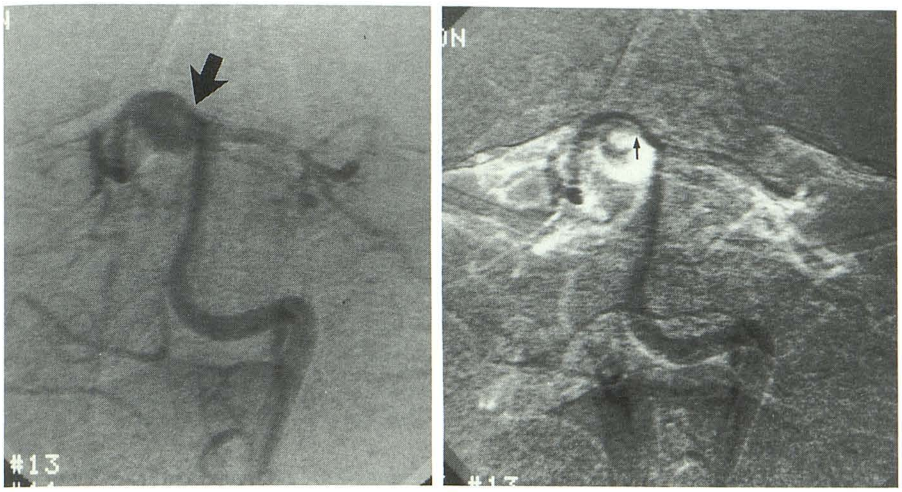
for angiographic diagnosis and aneurysm location are new. The use of sequential subtraction was described as a method of identifying and quantifying areas of slow flow in intracranial territories in cases of cerebral ischemia, flow through center venous malformations, and tumor circulation (4). The systolic jet and diastolic washout signs were first described as a method of identifying the parent vessel of a pseudoaneurysm in the lower extremities by Kreipke et al (5). This method takes advantage of the phenomenon of maximum filling at systole and emptying of blood during diastole. The importance of the jet was put forth as a reliable way to identify the aneurysm neck.

While the concept of using the jet sign as applied to cerebral aneurysms is descendant from that of the previous descriptions, there are some important differences. In a previous study, based on a biophysical model, it was shown that while the aneurysm tends to begin at a point where laminar flow in the center of a vessel strikes a bifurcation, contrast injected directly into the central laminar flow did not readily enter the dome (2). Even though the opening was approximately half the diameter of the lumen of the aneurysm, contrast did not enter. In our experiment, contrast enters the aneurysm but does not produce a jet. A possible explanation for this is pulsatile flow or elasticity of the aneurysm wall. As was pointed out by Kerber and Heilman (2), the use of biophysical models to draw conclusions is usually a treacherous exercise. On the other hand, our experience would indicate and our model seems to support the concept that the delayed mask technique is most useful in dealing with larger aneurysms. Fortunately, the jet phenomenon seems to be more reliably demonstrated precisely in these giant aneurysms where there is more doubt regarding the anatomy of the neck and the relationship to adjacent structures.

The technique may prove to be most useful when dealing with larger aneurysms in the region of the ophthalmic artery and intracavernous portion of the internal carotid artery (Figs. 3 and 4). In these patients, the decision to clip, trap, or balloon the aneurysm often depends on its origin relative to the dural reflections. While this technique obviously cannot make this determination directly, it may provide indirect evidence based on jet location relative to the anterior clinoid process and/or the ophthalmic artery. Additional useful information may also be obtained regarding large basilar tip aneurysms and middle cerebral artery aneurysms regarding the precise origin and location of the aneurysm to adjacent vessel origins.

While delayed masking is believed to be a better method of demonstrating abnormal vascular anatomy, other methods should also be mentioned, eg, carotid occlusion, rapid filming, and carotid compression during vertebral injection (6, 7).

In summary, the technique of utilizing a delayed mask for digital subtraction angiography is helpful in defining the neck of cerebral aneurysms and determining its position relative to the location of other vessels.




A B

Fig. 4. Basilar tip aneurysm.

This is patient 2 from Table 1. *A* is a traditionally masked Waters projection from the left vertebral artery injection. An aneurysm in the region in the basilar tip is seen (*arrow*). *B* shows the use of the delayed mask technique utilizing the same frame 13, as in *A* with the delayed mask, frame 14. The origin of the aneurysm can now be seen from the inferior surface of the posterior cerebral artery on the right (*B, arrow*).

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