Evaluation of the cerebral vasculature by intraarterial DSA – with emphasis on in vivo resolution

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Summary. Comparative study was performed between IA DSA and stereoscopic magnification angiography in relation to small vessel resolution, image quality of the vessels and image quality of various pathologic lesions. The vessels of various diameters, accurately measured by stereoscopic magnification angiography, were localized on IA DSA and their resolution was carefully assessed. The vessels more than 1 mm in diameter were equally visualized on IA DSA and conventional angiography. The vessels between 1 mm and 0.5 mm showed fair resolution on IA DSA, whereas IA DSA did not resolve the vessels smaller than 0.5 mm in diameter to good advantage. In addition, image quality of the vessels on IA DSA was compared with the conventional methods. Cerebral gyrus, venous sinuses, and intracerebral veins are often shown better on DSA. The small vessels such as lenticulostriate, small cortical, thalamoperforate and meningohipphyseal arteries were not defined on DSA. Equal or better image quality was obtained in more than 85% of cases with pathologic lesions. Examinations were performed faster with lower cost and lower complication rate. Information provided by DSA was often sufficient for managements of patients. Combined use of DSA and conventional angiography will improve diagnostic accuracy and decrease the complication rate.

Key words: DSA – vessel resolution – digital subtraction angiography – intraarterial DSA – IA DSA

Materials

From our files of IA DSA of the head and neck, 46 cases with various intracranial and extracranial abnormalities were selected for this study. Most cases underwent stereoscopic magnification angiography within short intervals from IA DSA, or stereoscopic magnification angiography and IA DSA were performed at the same sitting.
Equipment and angiographic techniques

**DSA:** The DSA unit used was a prototype by Shimadzu Corporation (DAR-100). The major components and their capabilities included a video camera of interlace type with the signal to noise ratio of 1000:1, a 22.9 cm diameter CsI image intensifier, 512 x 512 x 9 bit, 10 MHz A-D converter, and an X-ray tube with 400 kHU and 1.0 mm focus. The images were obtained with the serial mode of DSA, four frames being summed for final images. Filming speed was 1/s for 20 s or 2/s for 5 s, followed by 1/s for 10 s. Exposure factors for the head were 70–75 kVp and 300 mA. The images were recorded on X-ray films with a multiformat camera.

Most angiographic techniques for IA DSA were similar to those of stereoscopic magnification angiography, including the amount and flow rate of the contrast medium injection. Occasionally, a smaller amount of contrast medium, usually ½ to 1A of the conventional angiographic volume, was injected. Diluted contrast media, usually 2 to 3 times dilution, were also used, but the volume of injection was kept comparable to conventional angiography.

Straight anteroposterior, half-axial, and lateral projections were obtained as necessary for clinical situations.

Conventional angiography

The angiographic unit used in this study was a Shimadzu Pangiomax I (ER-100) [5, 7, 8], which was capable of biplane stereoscopic magnification angiography.

This system has a gantry which is capable of rotation and oscillation as well as tilting 30 degrees anteriorly and posteriorly for angled anteroposterior views. Three X-ray tubes, two Puck film changers, and an image intensifier are mounted on the gantry. The focus to film distance is always 100 cm. The X-ray tube for stereoscopic magnification contains two 0.2 x 0.2 mm focal spots (4 cm apart) which can tolerate 32 consecutive exposures (65 mA, 70 kVp, 0.1 second exposure) with three-phase full-wave rectification. Alternate exposures from the two focal spots are controlled by an electronic process.

In most neuroradiologic procedures, the twin focal spot tube is used for the lateral projection and the single focal spot tube is used for the anteroposterior projection. Occasionally, the tube positions are reversed since the unit has the capability of changing the tube positions by rotating the handle [7, 8]. Three exposures per 2 s for biplane angiography and three exposures per 1 s for single plane angiography are possible. No grid is used and high-speed ortho film/rare-earth screen combination is utilized.

The contrast medium used was 60% meglumine iothalamate injected into the common carotid, internal carotid, vertebral and external carotid arteries at flow rates of 8 ml/s for a total of 8 to 10 ml, 7 ml/s for a total of 7 to 8 ml, 6 ml/s for a total of 7 ml, and 3 ml/s for a total of 4 ml, respectively.

**Measurements:** Since our angiographic system has fixed focal-film distance, the following formula can be introduced,

$$M = 1 + \frac{W}{S}$$

where $M$ shows the magnification factor at the measuring point, $W$ indicates the distance between the two images of the measuring point on the stereoscopic pair and $S$ shows the distance between 2 focal spots [6, 8].

By using the above formula, the magnification factor ($M$) of a point or an object in the radiographic field can be accurately determined [8]. The true size or diameter can be calculated by dividing the measured value on the stereoscopic magnification angiograms by the magnification factor.

**Methods**

**Measurements**

DSA and stereoscopic magnification angiograms were reviewed at the same time. A rule marked to 0.1 mm was placed over the measuring point of the vessel on a stereoscopic angiographic film, and the inner diameter of the vessel was measured. Only points where the margins of the vessel were shown sharply were chosen for measurements. Often, magnifying glasses were used for these measurements, which were made as accurately as possible.

Arterial and venous phases of lateral projections were mainly utilized for this study.

Measuring points of 4 to 5 vessels whose calibres ranged approximately from 0.3 mm to 10 mm were chosen for the measurement on one of the stereoscopic angiographic pair and $W$ was determined by superimposing the second stereoscopic pair for each measuring point. The magnification factors of the measuring points were automatically obtained by using a conversion table from $W$ to $M$ based on the above formula [8]. The true vessel diameters at the specified measuring points were obtained by dividing the measured value by the magnification factor.