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Upright Catheter-Based Cerebral Angiography

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Abstract

Background—Several studies using Doppler ultrasound have suggested cerebral venous drainage is through paravertebral venous plexus due to the collapse of internal jugular veins in an upright position.

Methods—We present a technique of acquiring venographic images during an upright position as part of catheter-based angiography to provide additional information regarding cerebral venous diseases. Angiographic images in anteroposterior projection were acquired in lying position and after patients were placed at 60° using radiolucent supporting wedges on angiographic table.

Results—In the first patient, there was activation of the paravertebral venous plexus as supplemental venous drainage to right internal jugular vein and stenosis of left internal jugular vein in high cervical segment in the upright position. There was relative collapse of both internal jugular veins in the mid-cervical region. In the second patient, there was attenuation of contrast opacification of right posterior cervical veins and complete occlusion of right internal jugular vein proximal extracranial segment (high-grade stenosis in lying position). There was activation of additional supplemental drainage to left internal jugular vein including paravertebral venous plexus. In the third patient, there was exacerbation of stenoses of the left and right internal jugular veins proximal extracranial segment in the upright position (moderate stenoses in lying position). There was activation of additional supplemental drainage via paravertebral venous plexus to both internal jugular veins.

Conclusion—Our results demonstrate prominent changes in venous drainage patterns during upright angiographic images. Further studies would have to identify the patients in whom additional information in the upright angiography may provide clinically relevant information.

Keywords

Upright angiography; catheter-based angiography; cerebral venous disease; patient position; cerebral venous drainage

INTRODUCTION

Several studies using Doppler ultrasound have suggested cerebral venous drainage is predominantly through paravertebral venous plexus due to collapse of internal jugular veins [1,2]. There is variation in the positional change between individuals and depends upon the central venous pressure [1–3]. Previous studies have suggested that multiple compensatory pathways to internal jugular vein drainage in an upright position must exist to compensate for reduction in internal jugular venous drainage and some are not identified during Doppler studies [4]. The supplemental cerebral venous drainage can be classified into anterior (cavernous venous sinus draining into pterygoid plexus and retromandibular vein) and posterior drainage pattern based on venographic images acquired during angiography [5]. The posterior drainage pattern can be further divided into plexiform pattern (with sigmoid venous sinus draining into the paravertebral venous plexus), and solitary vein pattern

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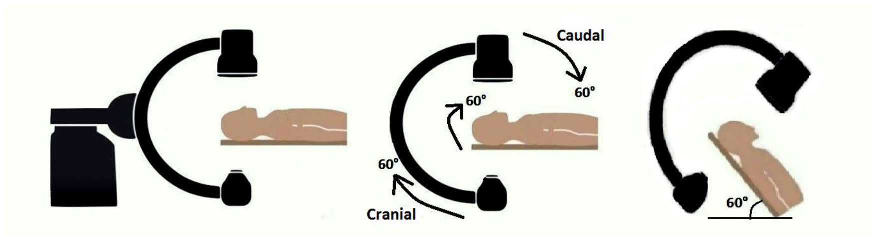

Figure 1. The positioning of patient and image intensifier for acquisition of the upright angiography.

(dominant single draining deep cervical vein) drainage. The posterior plexiform pattern can be further divided into two groups: posterior plexiform with or without prominent solitary vein. Therefore, investigators have suggested that imaging in the upright position is necessary due to a considerable change in cerebral venous flow to provide a comprehensive picture of the cerebral venous drainage [2]. We present a technique of acquiring venograpghic images during upright position as part of catheter-based angiography to provide additional information regarding cerebral venous diseases.

CASE DESCRIPTIONS

Patient 1

A 22-year-old man was evaluated for loss of visual acuity in right eye and intermittent alteration in left eye for last 12 weeks. The loss of visual acuity was described as patchy areas of visual obscuration within the visual field with symptoms worse in right eye. A fundoscopic examination demonstrated bilateral papilledema. The patient also had intermittent headaches which were worse during standing up. Patient was diagnosed with chronic myeloid leukemia and started on treatment 1 month ago and reported improvement in symptoms of headaches. A magnetic resonance venogram demonstrated a gap in the right transverse venous sinus with attenuated flow signal in right sigmoid venous sinus and internal jugular vein and magnetic resonance imaging demonstrated mild tonsillar descent in foramen magnum. A cerebral angiogram was performed to identify any cerebral venous occlusion or stenosis which may be contributing to suspected intracranial hypertension.

The cerebral angiogram was performed using a 5 F 100 cm GLIDECATH hydrophilic coated catheter (Terumo, Somerset, New Jersey, USA) through the transfemoral route. Images were acquired using Artis Q biplane floor-mounted system with mixed detectors (30 × 40 and 20 × 20) [focal spot size in mm: 0.3, 0.6, 1.0; image intensifier: 12 (15 inches; x-ray generator frequency: 100 kW (high frequency)] (Siemens, Muenchen, Germany) at 3 frames per second. The angiographic images demonstrated that right transverse venous sinus did not opacify with right internal carotid artery injection but opacified with right vertebral artery injection. The right transverse venous sinus was hypoplastic and right sigmoid venous sinus and right internal jugular vein were small. There was a stenosis of right internal jugular vein in high cervical segment. The right sigmoid venous sinus drains through posterior supplementary venous drainage and solitary vein pattern. The left internal jugular was large and dilated in the cervical segment.

For the upright angiography, the 5 F 100 cm GLIDECATH hydrophilic coated catheter (Terumo, Somerset, New Jersey, USA) was placed in the right internal carotid artery. Images were acquired in anteroposterior projection after 8 cc of contrast, VISIPAQUE 270(270 mgI/ml, iodixanol, GE Healthcare Ireland, Cork, Ireland) was injected. Subsequently, the patient was placed at 60° using radiolucent supporting wedges on the angiographic table. Images were acquired in anteroposterior projection after 8 cc of contrast, VISIPAQUE 270(270 mgI/mL, iodixanol) injection (GE Healthcare Ireland, Cork, Ireland) was injected. The image intensifier was positioned to acquire images in anteroposterior projection (see Figure 1). The images were compared to identify any new changes in the arterial or venous angiographic images (see Figure 2). In the upright position, there was an increase in caliber of lenticulostriate arteries particularly those that originate from proximal anterior cerebral artery in arteriographic images. In venographic images, there was activation of the paravertebral venous plexus as supplemental venous drainage to right internal jugular vein and stenosis of left internal jugular vein in high cervical segment. There was relative collapse of both internal jugular veins in mid cervical region.

No intervention was performed to treat the right internal jugular vein stenosis because of the presence of collateral drainage through paravertebral venous plexus in the upright position. At 1 month follow-up, patient reported

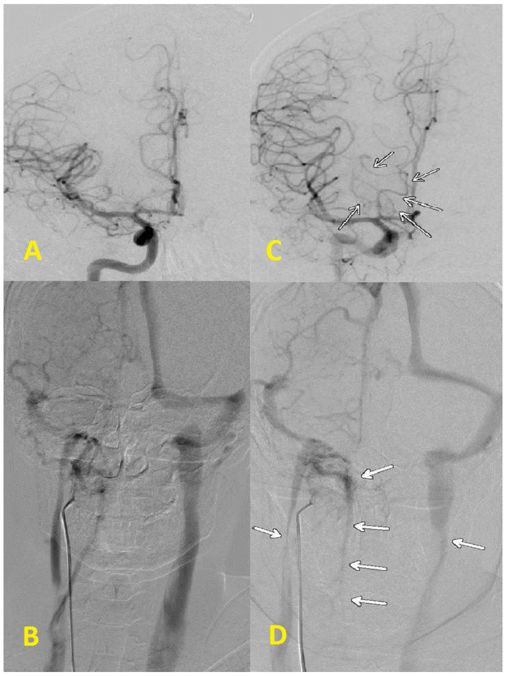

Figure 2. (A) and (B) The left side demonstrates angiographic images acquired in lying position. (C) and (D) The right panel demonstrates corresponding angiographic images acquired in the upright position. C: Arrows identify an increase in caliber of lenticulostriate arteries particularly those that originate from proximal anterior cerebral artery; D: arrows identify activation of the paravertebral venous plexus and relative collapse of both internal jugular veins in mid-cervical region.

complete resolution of headaches with improvement in visual acuity.

Patient 2

A 47-year-old man presented with left hemiparesis and dysarthria which started 5 days ago. Patient also reported intermittent stiffening of left upper and lower extremities. Patient had cerebral venous thrombosis 11 months ago and was on warfarin. The initial National Institutes of Health stroke scale score was 10. Computed tomographic scan of the head demonstrated right parietal intracerebral hemorrhage. Intravenous heparin was initiated because magnetic resonance venogram demonstrated occlusion in left transverse and sigmoid venous sinuses. A cerebral angiogram was perfumed to identify new changes and collateral patterns because patient had previous occlusion of left transverse venous sinus 11 months ago.

The cerebral angiogram was performed using a 5 F 100 cm GLIDECATH hydrophilic coated catheter (Terumo, Somerset, New Jersey, USA) through the transfemoral route. Images were acquired using Artis Q biplanefloor-mounted system with mixed detectors (30 × 40 and 20 × 20) (Siemens, Muenchen, Germany) at 3 frames per second. The arteriographic phase images demonstrated prominent vascularity on right hemispheric dura with arterial feeders from muscular branch from the right vertebral artery, and anterior and posterior branches of middle meningeal artery. The venographic phase images demonstrated that there was high-grade stenosis of right internal jugular vein in the high cervical segment. There was prominent posterior supplementary venous drainage through deep cervical veins. The left sigmoid venous sinus and left internal jugular vein were occluded in the proximal extracranial segment (Qureshi grade IIb) [6]. A segment of left transverse venous sinus was visualized which filled from the temporal vein. The transverse venous sinus drained through the occipital emissary veins into the deep cervical veins. The parietal cortical vein filled the superficial middle cerebral vein which drained into the cavernous sinuses and pterygopalatine venous plexus and retromandibular vein (Qureshi collateral grade III) [6]. There was a dural arteriovenous fistula that was formed between anterior branch of the middle meningeal artery right and cortical vein right hemisphere (parietal region). The cortical vein was dilated with retrograde filling and stasis.

For the upright angiography, the 5 F 100 cm GLIDECATH hydrophilic coated catheter (Terumo, Somerset, New Jersey, USA) was placed in the left vertebral artery. Images were acquired in anteroposterior projection after 8 cc of contrast, VISIPAQUE 270(270 mgI/ml, iodixanol) injection (GE Healthcare Ireland, Cork, Ireland) was injected. Subsequently, the patient was placed at 60° angle using radiolucent supporting wedges on the angiographic table. Images were acquired in anteroposterior projection after 8 cc of contrast, VISIPAQUE 270(270 mgI/ml, iodixanol) injection (GE Healthcare Ireland, Cork, Ireland) was injected. The image intensifier was positioned to acquire images in anteroposterior projection. The images were compared to identify any new changes in the arterial or venous angiographic images (see Figure 3). In the upright position, there was attenuation of contrast opacification of right posterior cervical veins and complete occlusion of the right internal jugular vein in high cervical segment (at site of high-grade stenosis in lying position) with increase in dilation of the segment prior to occlusion. There was a prominent increase in opacification of left transverse and sigmoid venous sinuses and activation of additional supplemental drainage to left internal jugular vein including paravertebral venous plexus.

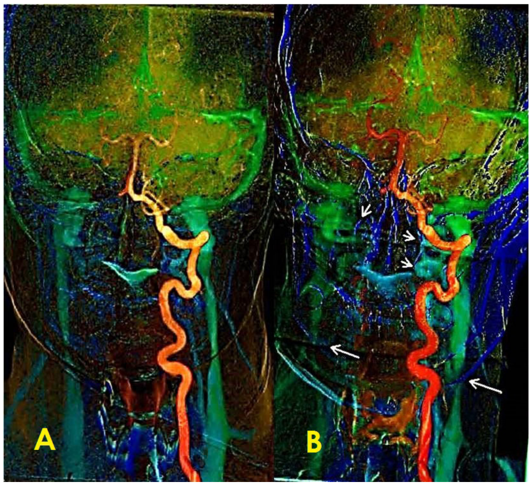

Figure 3. (A) The left panel demonstrates angiographic images acquired in lying position. (B) The right panel demonstrates corresponding angiographic images acquired in the upright position. A: arrows identify high-grade stenosis of left internal jugular vein; B: arrows identify occlusion of right internal jugular vein and attenuation of right deep posterior cervical vein and activation of the paravertebral venous plexus and contralateral venous channels. The images superimpose arterial phase on the venous phase.

Subcutaneous enoxaparin was started and patient underwent embolization for obliteration of dural arteriovenous fistula after 9 days.

Patient 3

A 42-year-old woman presented with an episode of syncope 3 weeks ago and another episode of left hemiparesis 2 weeks ago. Patient reports intermittent episodes of speech difficulty and near syncope. The patient had a stroke 1 year ago which resulted in right hemiparesis and required a walker for ambulation since discharge. The patient was an active cigarette smoker (1/2 packet/day) for 20 years. On examination, the patient was noted to have a left hemiparesis with a National Institutes of Health stroke scale score of 3. On magnetic resonance imaging, scattered foci of hyperintensity were noted in the supratentorial white matter of both cerebral hemispheres on fluid-attenuated inversion recovery sequence. A computed tomographic angiogram demonstrated a large aneurysm that involved the high cervical segment of right internal carotid artery.

The cerebral angiogram was performed using a 5 F 100 cm GLIDECATH hydrophilic coated catheter (Terumo, Somerset, New Jersey, USA) through the transfemoral route. Images were acquired using Artis Q biplanefloor-mounted system with mixed detectors (30 × 40 and 20 × 20) (Siemens, Muenchen, Germany) at 3 frames per second. The arteriographic phase images demonstrated an aneurysm that originates from distal cervical portion of the right internal carotid artery. The aneurysm pointed superiorly and measured 9 × 6 mm. The venographic phase images demonstrated that there was high-grade stenosis of right internal jugular vein in the high cervical segment. There was prominent posterior supplementary venous drainage through deep cervical veins. There was moderate stenosis of both internal jugular veins in proximal extracranial segment. The left internal jugular vein was larger. There was posterior supplemental venous drainage (plexiform pattern) to left internal jugular vein.

For the upright angiography, the 5 F 100 cm GLIDECATH hydrophilic coated catheter (Terumo, Somerset, New Jersey, USA) was placed in the left vertebral artery. Images were acquired in anteroposterior projection after 8 cc of contrast, VISIPAQUE 270(270 mgI/ml, iodixanol) injection (GE Healthcare Ireland, Cork, Ireland) was injected. Subsequently, the patient was placed at 60° using radiolucent supporting wedges on the angiographic table. Images were acquired in anteroposterior projection after 8 cc of contrast, VISIPAQUE 270(270 mgI/ml, iodixanol) injection (GE Healthcare Ireland, Cork, Ireland) was injected. The image intensifier was positioned to acquire images in anteroposterior projection. The images were compared to identify any new changes in the arterial or venous angiographic images (see Figure 4). In the upright position, there was a marked increase in severity of stenosis documented in supine position of left internal jugular vein in proximal extracranial segment with dilation of the pre stenotic segment. There was activation of the paravertebral venous plexus on left side. There was an increase in the severity of stenosis documented in supine position of right internal jugular vein in proximal extracranial segment and activation of the paravertebral venous plexus to a smaller magnitude.

No intervention was performed to treat the left internal jugular vein stenosis because of the presence of collateral drainage through paravertebral venous plexus in the upright position and lack of clinical symptoms.

DISCUSSION

The observations made in our study demonstrate prominent changes in the venous drainage patterns during upright angiographic images. The internal jugular vein flow was changed in the upright position in all patients. In the first patient, the internal jugular vein opacification

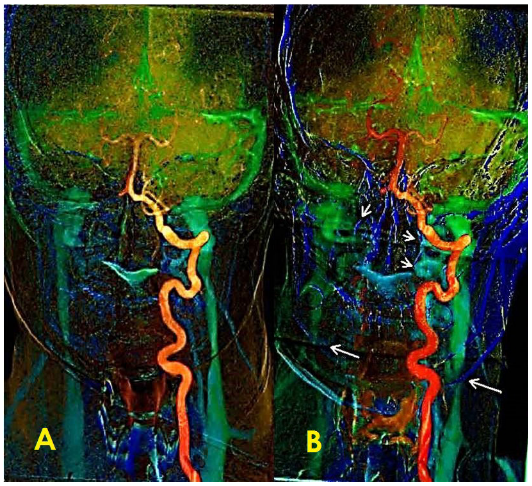

Figure 4. (A) The left panel demonstrates angiographic images acquired in lying position. (B) The right panel demonstrates corresponding angiographic images acquired in the upright position. A: arrows identify high-grade stenosis of left internal jugular vein; B: arrows identify high-grade of right internal jugular vein and activation of the paravertebral venous plexus and contralateral venous channels particularly prominent on left side. The images superimpose the arterial phase on the venous phase.

was attenuated with activation of supplemental venous drainage. In the second patient, there was occlusion of right internal jugular vein at site of high-grade stenosis and attenuation of supplemental deep cervical vein opacification with a compensatory increase in the flow on contralateral side. In the third patient, there was exacerbation of stenosis of the left and right internal jugular veins in proximal extracranial segment in the upright position. There was activation of additional supplemental drainage via paravertebral venous plexus to both internal jugular veins. Acquiring upright images during catheter-based angiography can provide detailed information regarding magnitude of lumen reduction in internal jugular or deep cervical veins and identify the supplemental venous channels activated for compensation.

The procedure requires identification of the artery (internal carotid or vertebral artery) which is opacifying the venous drainage of interest (dural venous sinuses and internal jugular vein). The second part of the procedure is achieving the upright position of the patient. This portion appears to be challenging due to lack of specific supporting equipment to maintain patient in the desired position and angulation of the anteroposterior image intensifier to adequately visualize the region of interest. In our current setup, the angiographic table does not have tilt function so patient positioning has to be manually maintained. The current image intensifier cannot be placed in position to acquire anteroposterior projection in a completely upright person. The caudocephalic projection is limited by the interspersed angiographic table within the field of rotation.

CONCLUSION

Further studies would have to identify the patients in whom additional information in the upright angiography may provide additional clinically relevant information. Potentially patients in whom supine angiography with venous phase images does not provide an adequate diagnosis and those in whom symptoms are exacerbated during the upright position may benefit from such additional imaging. Furthermore, identification of venous outflow patterns in the upright position may be valuable in patients with conditions such as dural arteriovenous fistulas and idiopathic intracranial hypertension that are associated with venous hypertension secondary to stenosis in outflow veins [7–11]. A higher proportion of patients with dural arteriovenous fistulas may have stenosis or collapse of internal jugular veins in the upright position. Patient with internal jugular vein occlusion or stenosis demonstrated on supine angiography with venous phase images should have an upright imaging to identify the full magnitude of supplemental venous drainage associated with target internal jugular vein prior to recanalization using angioplasty and/or stent placement [12,13]. The inconsistent effect on venous flow velocity on Doppler ultrasound [14] and limited clinical improvement with angioplasty and stent placement for internal jugular vein stenosis or occlusion [15] may be partly explained by underestimation of supplemental venous channels and overestimation of the role of internal jugular vein during upright position.

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