Jugular venography for evaluation of abnormalities of the skull base

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Jugular venography done to evaluate abnormalities at the base of the skull demonstrated three distinctly different patterns depending on whether there is occlusion, invasion, or growth within the internal jugular vein. Improper technique results in a lack of intracranial dural sinus filling which may masquerade as venous occlusion. This problem is avoided by adequate neck compression along with proper volume and rate of delivery of contrast. Radiographically, an abnormal jugular vein at the base of the skull will show a concave defect in true occlusion, constriction or invasion of the vein by tumor, or tumor growth within the vein.

KEY WORDS • jugular venography • base of skull, tumors • jugular foramen • glomus jugulare tumors

Jugular venography is a valuable radiographic procedure which may be particularly useful in the diagnosis and surgical management of patients with abnormalities at the base of the skull and in the high cervical area. Specifically, it is valuable 1) to determine the presence and extent of a mass at the base of the skull, 2) in the work-up of an unexplained jugular foramen syndrome, 3) in fractures of the skull base with cranial nerve damage, 4) for suspected abnormalities of the jugular vein within the neck, and 5) to determine if a neck approach is necessary along with intracranial surgery for complete removal of tumors at the base of the skull.

The normal anatomical and radiographic relationships of the jugular vein, dural sinuses, and the skull base have been described before and will not be dealt with here.

Although the various techniques of performing retrograde jugular venography have been described, those errors which may lead to a misinterpretation of the procedure have not been stressed. This article describes technical and interpretive pitfalls to avoid, and presents criteria which have not been previously enumerated and which must be present in order to diagnose a positive jugular venogram.

Technique

Either of two methods can be used. After applying a jugular vein compression device, a direct percutaneous puncture of the internal jugular vein at the level of C-3 is made. An exchange is made for a 9-cm No. 6 French polyethylene catheter. The alternative method involves the femoral vein approach in which a catheter of adequate diameter (No. 4
to No. 7 French, depending on the patient's age) is advanced through the right side of the heart and then into either the right or left internal jugular vein. The latter approach is less desirable for reasons described below.

The abundance of cervical venous drainage into the internal jugular vein makes it imperative that in either method the catheter be advanced so that its tip will lie at, or just below, the superior bulb of the internal jugular vein. The direction in which the tip is pointed is likewise important. If the catheter tip is directed posteriorly within the bulb there may be exclusive filling of the sigmoid and transverse sinus without opacification of the inferior petrosal sinus. Conversely, reflux into the cavernous sinus by way of the inferior petrosal sinus is best obtained with the catheter tip directed anteriorly. Under fluoroscopy the catheter position and the direction in which the tip is pointed can be determined and altered as necessary.

A machine injection of 60 cc of Renografin-60 delivered over a 6-second period (10 cc/sec) is necessary to adequately fill the cervical veins and dural sinuses in the adult. The compression device remains in place during the injection and filming. In addition to the lateral view, the anteroposterior view that we prefer is the extended Water's view (45° to the canthomeatal line) for it shows best the jugular foramen on end. A film is taken 1 second prior to injection and the filming sequence is 1 film per second for 10 seconds. The preinjection film is necessary if subtraction films are desired.

There are technical problems which, if not remedied, may lead to an inadequate or misinterpreted study. If the jugular vein is inadequately compressed below the catheter tip, there may be a lack of retrograde filling into the dural sinuses. The remedy is to test injected contrast material by hand under fluoroscopy and if the neck compression is sufficient then stasis in the jugular vein will be observed. An inadequate injection may be caused by either an insufficient volume or a poor delivery rate of the contrast material. Since it is difficult to rapidly deliver a volume of 60 cc by hand, machine injection is preferred. If the femoral vein approach is being used, and particularly if the patient is a
Jugular venography for skull base abnormality diagnosis

child, the combined effects of a narrowed inside diameter of the catheter and the length of the catheter itself lessens the ability to deliver the volume of contrast over a relatively short period of time (flow-rate limitation). For this reason, whenever possible, we recommend a direct jugular vein puncture rather than the indirect femoral vein approach.

**Case Reports**

Six patients, in whom jugular venography was employed, are presented below. The first case which is a false positive venogram is particularly instructive because following this study we set up criteria which must be met in interpreting jugular venograms. Cases 2, 3 and 4 were examples of glomus jugulare tumors each resulting in completely different venographic appearance. Case 5 shows the effect a nasopharyngeal carcinoma can have on the jugular vein when it invades the base of the skull. Case 6, a bullet wound at the base of the skull, again illustrates the value of preoperative jugular venography.

**Case 1**

A 45-year-old man entered the hospital with a chief complaint of pain on the right side of the face, diplopia, and decreased hearing on the right. Plain skull films and tomograms demonstrated bone destruction at the skull base and a soft tissue mass in the sphenoid and right ethmoid sinus.

A retrograde jugular venogram (Fig. 1) was initially interpreted as obstruction of the right jugular vein at the jugular foramen. An arteriogram showed encasement of the right internal carotid artery in its petrous, pre cavernous, and cavernous portions with faint hypervascularity of the mass at the skull base. On the venous phase, there is normal visualization of the right transverse sinus, and the base view (Fig. 2) best shows normal filling of the right jugular vein. The preoperative diagnosis of a nasopharyngeal carcinoma which had invaded the base of the skull and encased the right internal carotid artery was confirmed at surgery.

The arteriogram showed normal patency of the right internal jugular vein while at venography this structure seemed to be occluded at the jugular foramen. The appearance of this venogram should be kept in mind while studying the following venograms. Their significance will be discussed below.

**Case 2**

This 60-year-old man presented a 5-year history of tinnitus and gradual hearing loss on the right. Skull series and tomograms revealed erosion of the right jugular tubercle, widening of the jugular fossa, and erosion into the tympanic cavity. A venogram (Fig. 3) showed a concave filling defect of the jugular vein below the level of the superior bulb. Carotid and vertebral angiography showed a highly vascular mass in the jugular fossa fed primarily by the inferior tympanic branch of the ascending pharyngeal artery and the posterior auricular branch of the external occipital artery. Arterial venous shunting into the transverse sinus was evident. Because of the obstruction to the venous outflow on the right, the blood flow was across the confluence of the sinuses, through the left transverse sinus, and down the left internal jugular vein.

A preoperative diagnosis of a glomus jugulare tumor which had grown inferiorly from the jugular bulb into the upper cervical area was confirmed at surgery. Total tumor removal was accomplished by a combined intracranial and cervical approach.
Case 3

A 46-year-old woman, with a 3-year history of gradual decrease in hearing on the right and a recent onset of a right facial paralysis, was found to have a pulsatile mass presenting behind the right tympanic membrane.

Plain film examination showed extensive erosion of the right tympanic cavity, clouding of the mastoid air cells, and irregular erosion of the jugular fossa. Carotid and vertebral arteriography demonstrated a highly vascular mass in the right jugular fossa and right middle ear with early arterial venous shunting. The venous phase showed filling of both transverse sinuses; however there was better opacification of the opposite (left) transverse sinus and jugular vein. Although predominant outflow via the left side may have been normal in this patient, a venogram was performed to exclude partial venous occlusion within the right jugular fossa. The early film (Fig. 4) shows a smooth extrinsic compression of the jugular vein. Later films (Fig. 5) show that the obstruction is partial and dural reflux was achieved.

Preoperative percutaneous embolization resulted in a significant diminution of the blood supply to this mass. At surgery a glomus jugulare tumor was removed with little blood loss and it was found to partially occlude the internal jugular vein by external compression just below the level of the jugular fossa.

Case 4

In this patient, on whom no history is available, a glomus jugulare tumor was seen...
Jugular venography for skull base abnormality diagnosis

Case 3

Later phase of the venogram demonstrates dural reflux despite this partial obstruction.

1 = smooth extrinsic compression of the right jugular vein, 2 = right inferior petrosal sinus, 3 = right transverse sinus, 4 = left transverse sinus, 5 = left jugular vein.

Growing within the jugular vein (Fig. 6) and at the same time expanding the vein. For total tumor removal a combined intracranial and neck approach would be necessary.

Case 5

A 65-year-old woman, with a 9-month history of nasal stuffiness, developed dysphagia, numbness of the left face, and hoarseness 4 weeks prior to admission. Neurological examination revealed a left Horner's syndrome, and left 5th, 9th, 10th, 11th, and 12th cranial nerve dysfunction. Skull films showed a mass in the nasopharynx and bone destruction at the base of the skull. A jugular venogram (Fig. 7) shows partial venous obstruction.

Fig. 5. Case 3. Later phase of the venogram demonstrates dural reflux despite this partial obstruction. 1 = smooth extrinsic compression of the right jugular vein, 2 = right inferior petrosal sinus, 3 = right transverse sinus, 4 = left transverse sinus, 5 = left jugular vein.

Fig. 6. Case 4. The jugular vein is expanded and the tumor growing within the vein (arrow) is causing complete venous obstruction.
obstruction to the retrograde flow of contrast material. The irregular extrinsic compression of the vein suggests vascular invasion by the mass. Biopsy of the nasopharynx revealed undifferentiated nasopharyngeal carcinoma and a course of radiation therapy was given.

Case 6

This 55-year-old man was shot in the neck and was admitted with swelling in the neck and a left 12th nerve paralysis. Skull films with tomography revealed a fracture of the jugular tubercle. Because of the position of the bullet, the swelling of the neck, and the fractured jugular tubercle, a venogram was performed (Fig. 8). A concave defect completely obstructing the left jugular vein is seen at the level of jugular fossa. A carotid arteriogram showed only mild deviation of the cervical portion of the left internal carotid. At surgery a large blood clot in the jugular vein was removed along with the bullet from the soft tissues of the neck.

Discussion

The following are pathological conditions that may cause an abnormal jugular venogram:

Presenting as a Mass
1. Glomus (tympanicum or jugulare) tumor
2. Nasopharyngeal carcinoma
3. Intracranial abscess secondary to chronic mastoiditis
4. Neurofibroma (specifically IX, X, XI)
5. Acoustic neuroma
6. Meningioma
7. Foreign body in the jugular fossa
8. Chordoma
9. Carcinoma of the middle ear.

Presenting as a Thrombus
1. Basilar skull fracture
2. Meningitis
3. Phlebitis
4. Coagulopathy
5. Dehydration.

As indicated, compression or obstruction of the jugular vein may be caused by a mass or by thrombosis. It is clear that of these entities a number arise primarily within the auditory apparatus or erode directly into the temporal bone and that jugular venography can help in assessing the extent of surgery necessary for complete removal.

In a collection of 18 cases of glomus tumors, 16 showed positive retrograde jugular
Jugular venography for skull base abnormality diagnosis

Fig. 8. Case 6. A concave defect (arrow) within the left jugular vein completely obstructs the retrograde flow of contrast. The bullet is lodged in the soft tissues of the neck, just lateral to the left jugular vein.

venograms. It is mentioned that only vein compression with an intravascular filling defect is characteristic of a glomus tumor (similar to Case 4) and that external compression of the vein or a nonexpansible concave obstruction may be due to causes other than a glomus tumor.

What additionally needs to be stressed is the significance of the lack of reflux from the jugular vein into the dural sinuses. In the section on technique we have described that inadequate neck compression or the delivery of an insufficient amount of contrast material may result in no dural reflux. However, because of the normal variation in venous drainage into the internal jugular vein, a similar lack of dural reflux may result from anatomical variations, rather than indicating a pathological state. Shiu, et al., state that only in 45% of cases is there direct drainage from the inferior petrosal sinus into the jugular bulb. In the remainder of cases, the inferior petrosal sinus drains into a communicating vein that unites the jugular bulb with the deep cervical plexus or the inferior petrosal sinus is poorly formed and there exists instead a plexus of veins. No direct connection between the inferior petrosal sinus and the jugular vein exists in 7% of the cases, since the drainage is directly into the deep cervical plexus of veins. While there is normally a direct continuation between the superior bulb of the jugular vein and the sigmoid sinus, if during venography the flow of contrast is directed anteriorly from the catheter tip and the situation exists where there is no connection between the jugular vein and the inferior petrosal sinus there may be no intracranial reflux. In Case 1, although there was a lack of retrograde filling from the internal jugular vein, cerebral angiography showed patency of the venous outflow on the same side proving that no obstruction existed. We postulate in this case a lack of a normal direct venous connection between the inferior petrosal sinus and the internal jugular vein. This combined with an anteriorly-positioned catheter tip during contrast injection resulted in no intracranial dural reflux. Repositioning of the catheter posteriorly during injection would have opacified the sigmoid and transverse sinus.

Figure 9 depicts the various configurations the jugular vein may have in both pathological and normal cases. A smooth concave border of the superior bulb is the clue that there is no obstructing mass in spite of the lack of dural reflux. A concave defect, extrinsic compression, or an expanded vein with tumor growth inside are the criteria which we feel should be met in order to diagnose a positive jugular venogram. A narrowed jugular vein with angular and irregular walls suggests that there has been actual tumor invasion of the vascular wall (see Case 5). A smooth extrinsic compression of the jugular vein indicates adjacent mass effect without radiographic evidence of tumor invasion (see Case 3). Given the histological diagnosis, the presence or absence of vascular invasion may have a decided effect on the operability of the mass. The obstruction associated with these defects may be complete or partial.

Conclusions

To determine the extent of lesions found within the temporal bone or at the skull base, jugular venography is often employed. The information obtained from this procedure will determine 1) if the jugular vein is patent, 2) if there is partial or complete venous occlusion at the jugular foramen, or 3) if the mass has grown from the skull base inferiorly within the jugular vein, which usually necessitates a
combined head and neck approach for complete tumor removal. There are both technical and interpretive sources of error which may give the impression of jugular vein involvement when, in fact, it is normal. Adequate neck compression, delivery of a sufficiently large volume of contrast material, and proper injection pressure are technical necessities. The lack of dural sinus reflux from the jugular vein can cause an interpretive error, and should be avoided. Pathological jugular venograms show three distinctly different patterns depending on the mode of a tumor growth.

References


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