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Cavernous sinus lesions biopsy with neuronavigation and tip-cut needle

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Abstract

Background: Transoval biopsy of cavernous sinus (CS) lesions is the last non-invasive diagnostic option in those 15% of patients in whom etiology remains unclear in spite of extensive neuroradiological imaging, clinical assessment, and laboratory evaluation. However, there are no guidelines defining indications and the most appropriate technique for this procedure.

Case Description: We present four patients in whom we performed X-ray and neuronavigation-assisted transoval CS biopsies using tip-cut needles.

Conclusion: The technique described allows the operator to determine the optimal angle for entering the CS, avoiding the complications due to distorted anatomy, and facilitating orientation once inside the CS. It reduces both radiation exposure as well as general anesthesia duration.

Key Words: Cavernous sinus lesions, foramen ovale biopsy, minimally invasive biopsy, tip-cut needle, transoval approach

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INTRODUCTION

The cavernous sinus (CS), described by Dwight Parkinson as an "anatomical jewel box," can contain lesions of different pathological nature.[8]

Correct diagnosis is thus essential for safe and successful treatment.[11]

Since it was first performed by Stechison in 1989, minimally invasive biopsy through foramen ovale has become the gold standard non-invasive diagnostic procedure for the 15% of CS lesions in which clinical, laboratory, and imaging studies fail to identify the exact nature of the process.[9]

A number of biopsy techniques have been developed over the years, reflecting the advances in cerebral imaging and bioptic instruments.

The present paper describes a CS transoval lesion biopsy technique using a frameless image-guidance and a frontal tip-cut biopsy needle.

CASE REPORTS

Case 1

A 76-year-old woman with no previous history of cancer presented with intractable headache followed by diplopia and left hemifacial numbness lasting for 2 weeks.

Cerebral magnetic resonance imaging (MRI) showed a CS lesion extending to the Meckel's cave. The patient underwent a transoval biopsy of the lesion. Histopathology confirmed an adenocarcinoma metastasis of unknown origin. She was subsequently treated with stereotactic radiosurgery (SRS).

Case 2

A 40-year-old, 16 weeks pregnant, HIV- and hepatitis C virus (HCV)-positive woman presented with a 6-day history of bilateral diplopia, frontal headaches, and left eye ptosis. Non-contrast enhanced cerebral MRI revealed a CS lesion extending to the Meckel's cave. In view of the patient's history, we were quite reluctant to rule out infectious etiology on the basis of neuroimaging studies alone. In spite of steroid treatment, both diplopia and ptosis worsened over the next few days. Following a discussion of intended benefits and potential risk of the procedure, an informed consent for transoval biopsy was obtained. Contrast MRI and computed tomography (CT) using abdominal protection was obtained. Histology implied a typical World Health Organziation (WHO) Grade I meningioma. Given the benign nature of the lesion and the patient's pregnancy, we refrained from urgent SRS.

Case 3

A 60-year-old male with a 3-year history of CS syndrome consisting of left ptosis, diplopia, and ipsilateral exophthalmos presented with a sudden deterioration of his symptoms. Cerebral MRI showed a CS lesion with posterior extension to the Meckel's cave. He underwent transoval biopsy of the lesion. Histology revealed an atypical WHO grade II meningioma and SRS treatment was commenced.

Case 4

A 37-year-old male with previous surgery for right eye convergent strabism at the age of 19 was admitted with sudden onset of complete right-sided ptosis, non-reactive mydriasis, and abducent palsy. Neurological examination showed right-sided hemifacial numbness and masticatory muscle atrophy. Cerebral MRI revealed a CS lesion with extension to the Meckel's cave. The patient underwent transoval percutaneous biopsy of the lesion which yielded a histopathological diagnosis of atypical WHO grade II meningioma. He was then treated with SRS.

Biopsy technique

The transoval biopsy as described was performed under neuronavigation and fluoroscopic real-time guidance [Figure 1]. CT, MRI, and 3D angio-MRI scans with reconstruction of the whole face and skull were obtained before every procedure. A pre-operative trajectory was calculated using the neuronavigation system (StealthStationTREON plus; Medtronic) by fusing the images (Stealth application software Cranial 5) of the CT skull anatomy (foramen ovale) with the MRI image of the lesion, soft tissues, and vessels (carotid artery). The depth and volume of the biopsy target were also calculated and integrated into the operative plan. General anesthesia with orotracheal intubation was used. The patients were positioned supine with the head fixed in a three-pin Mayfield head holder. The fluoroscopic intensifier and the neuronavigator were used to guide the procedure both during the extra- and intra-cranial phases.

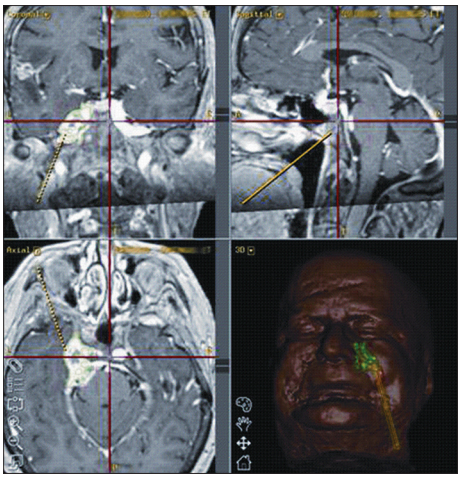

Figure 1: Neuronavigation screenshots demonstrating the capability of multiplanar image reconstruction, which allows for a 3D view of the lesion and needle pathway with image fusion of the CT skull anatomy (foramen ovale) with the MRI image of the lesion, soft tissues, and vessels (carotid artery)

Following sterile preparation of the skin, local anesthetic (lidocaine) was injected locally through an entry point located 2.5 cm laterally to the labial commissure and down to the foramen ovale. This entry point was identified with the aid of the neuronavigation system as per the classic approach to the foramen ovale described by Hartel.

The neuronavigation needle (Sure track system) [Figure 2] was inserted percutaneously and advanced under fluoroscopic [Figure 3] and frameless stereotactic guidance until the foramen ovale was entered. A coaxial frontal tip-cut 17 gauge needle (Biopince; Angiotech, Vancouver, BC, Canada) [Figure 4] was inserted through the needle canula to a pre-calculated depth. The biopsy specimen was then cut and removed by the frontal cut tip under both fluoroscopic and neuronavigation guidance. Finally the needle was removed. The mean total duration of the procedure was 40 min. All the tissue samples were cut and stained with hematoxylin and eosin for optical microscope evaluation at neuropathology laboratory [Figure 5].

We encountered no intra- or post-operative complications.

DISCUSSION

A large variety of pathological lesions can occur in the CS.

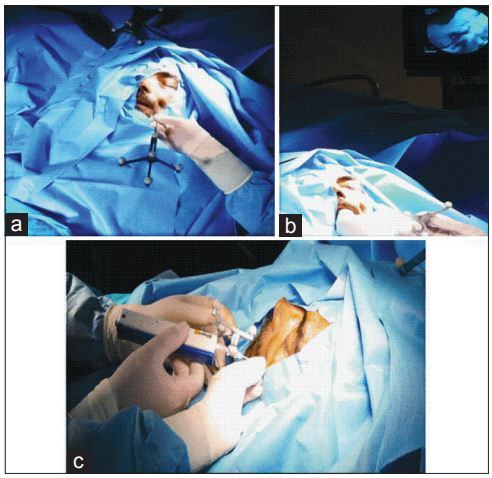

Figure 2: Intraoperative phases: (a) evaluation of best entry angle by neuronavigation assistance, (b) intra-cavernous needle localization double confirmation by RX and neuronavigation, (c) neuronavigated frontal cut biopsy

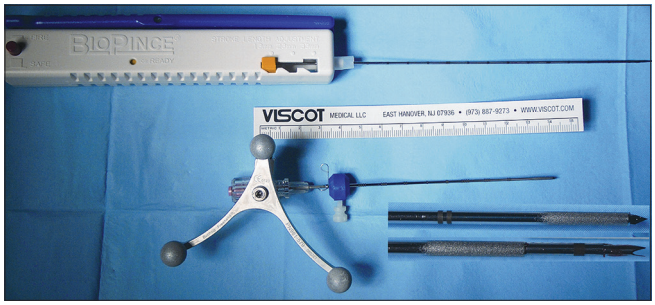

Figure 4: Neuronavigation needle (Sure track system) and coaxial frontal tip-cut 17 gauge needle (Biopince; Angiotech)

However, benign and malignant tumors are the most frequently encountered lesions in this area, with meningioma being the most common.[5]

Differentiation of these deep lesions is essential for determining the most appropriate treatment option and, hence, reducing the complications of both surgical[3] and non-invasive approaches.[7,10]

Transoval biopsy of CS lesions is the last non-invasive diagnostic option in those 15% of patients in whom etiology remains unclear in spite of extensive neuroradiological imaging, clinical assessment, and laboratory evaluation. It is particularly valuable in cases where inflammatory or malignant lesions with "meningioma-like" appearance on imaging could be mistaken for a true meningioma.[10]

The transoval foramen biopsy route was first described by Stechison (1989) in a case of breast cancer metastasis to the CS.[13] This anatomical approach was inspired by Hartel's technique for the treatment of trigeminal neuralgia, which was initially described in 1912 and later adopted by most authors.[4]

Despite the low incidence of complications,[6] CS biopsy carries significant risks because of the intrinsic anatomical

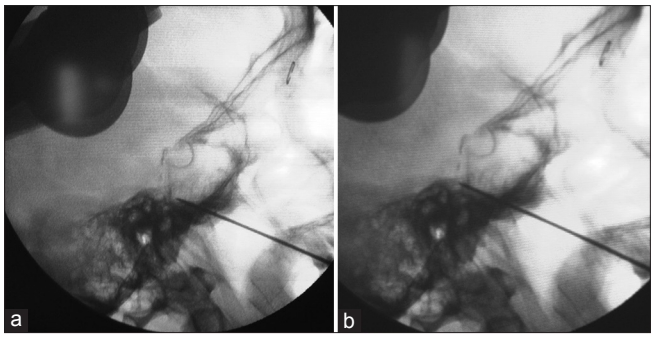

Figure 3: Intraoperative RX control confirming: (a) needle tip correct localization in Meckel's cave and (b) needle tip within the lesion

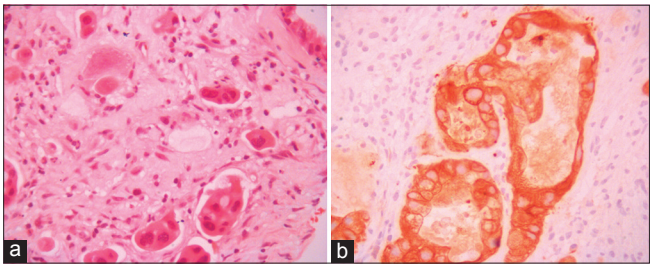

Figure 5: Histological evaluation of a tumor specimen obtained through transoval biopsy describing: (a) rests of epithelial cells in a mesenchymal stroma, forming circular cavities (H and E, ×40); (b) strong CK7 cytokeratine immunoreactivity. The histological diagnosis was of metastasis of adenocarcinoma of unknown primary tumor

characteristics of the lesion biopsied, its location, and the structures traversed en route to the CS.[1]

This is why several biopsy techniques, using a variety of needles and intra-operative imaging methods, have been developed over the years.

Fluoroscopy and/or CT-guided techniques[2] still predominate in literature even though some authors (such as Paul Penar[14]) consider them anachronistic in the present era of frameless neuronavigation. In some cases, the patient even had to be transferred from the operating theater to the CT suite for routine verification of the needle depth.[2,14] In our opinion, this practice results in unnecessary prolongation of the procedure, exposure to general anesthesia, and exposure of the patient to excessive radiation. Avoidance of unnecessary radiation exposure is particularly important in pregnant patients, as described in one of our cases.

Use of obsolete biopsy needles has also been strongly criticized. In particular, Dolenc argued that using a large-bore 14 gauge Tuohy needle turns the procedure into an invasive one. The risk is further increased by the curette effect of a strong aspiration, as described by Sindou.[12]

Side-cutting aspiration type needles with a diameter ranging from 14 to 22 gauge were the only alternatives described in the literature. In spite of criticism, no other needle design has been employed until now.

We describe a novel X-ray and neuronavigator-assisted technique in which fused CT and angio-MRI images serve as a base for planning the ideal needle trajectory and guiding its advancement by 3D virtual intra-operative control. This allowed us to tailor the procedure to each patient's bony, vascular, and soft tissue anatomy. Unlike fluoroscopy, this technique proved useful even in the context of a pathologic CS in which the normal vascular anatomy is altered by a potentially highly vascularized lesion. Contrary to the case report by Frighetto,[3] we did not completely rely on neuronavigation. We believe that judicious use of fluoroscopy provides valuable real-time intra-operative anatomic information without prolonging the general anesthesia or delivering excessive radiation. This was especially important in the case of our pregnant HIV-positive patient, where an X-ray belly-protective coat was used to screen out the fetus.

In the four cases presented, we chose a frontal cut needle, which gave us the advantage of reaching the lesion by advancing the needle 0.5 cm less than would have been necessary with a laterally fenestrated biopsy needle. Its tip opening reduced the risk of tearing the intracavernous segment of internal carotid artery.

CONCLUSIONS

Despite the low incidence of complications, biopsy of CS lesions should be considered a high-risk procedure. This is not only due to the complex peri- and intra-cavernous anatomy, but also due to the fact that the operator is "nibbling" blindly at very deep and potentially highly vascularized target.

In our opinion, the approach guided by neuronavigation and X-ray is both the easiest and most reliable of the transoval percutaneous biopsy techniques. The technique described safely allows the neurosurgeon to choose the best needle entrance angle, avoids the pitfalls associated with distorted anatomy due to small foramina, and keeps the operator well oriented once inside the CS. Finally, it avoids excessive dose of ionizing radiation and shortens the duration of general anesthesia to a mean of 40 min. In view of our satisfying results, we are optimistic that future experience shall confirm the superiority of the frontal cut needle for all the biopsy techniques.

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