Evaluation of the Use of Intraoperative Ultrasound in Resection of Intraaxial Posterior Fossa Lesions

A thesis submitted for fulfillment of M.D. degree in neurosurgery

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Table of contents:

List of figures:

	C) Microscopic picture of pilocytic astrocytoma. D) IOUS image for the same patient.
15	*A) MRI Axial T1WI with contrast of a case of ependymoma B) Sagittal T1 WI MRI with showing typical feature of ependymoma with growth of through foramen of the fourth ventricle. C) Microscopic picture of ependymoma D) IOUS image of an ependymoma.*
16	*A) Axial T1WI MRI for a case of hemangioblastoma. B) Sagittal T1 WI MRI of a case of hemangioblastoma. Notice the strong enhancement of contrast. C) Microscopic picture of one of the hemangioblastoma cases. D) IOUS picture of the same hemangioblastoma case.*
17	*A) Axial T2 MRI of a case of 4^{th} ventricular epidermiod. B) T1 WI of the same case. C) Intraoperative appearance of epidermiod. D) IOUS image of epidermiod case.*
18	A & B) Axial and coronal MRI of a case of posterior fossa brain metastasis (lung)
19	*T1WI with contrast MRI of a cerebellar abscess*
20	*T1 sagittal MRI with contrast, which shows a fourth ventricular enhancing choroid plexus papilloma*
21	*Intraoperative neuronavigation system (Infrared camera, Computer station and monitor*
22	A*) It shows the high field intraoperative MRI with sliding magnet. B) It shows the ultra low field polar star iMRI with the stealth system*
23	*It shows the first iMRI introduced by Black et al.* *A) View on the iMRI from the control console. B) A vie from the back of the surgeon. C) OR setting. D) A view with the microscope inbetween the magnet.*[17]
24	*A) Showing the intraoperative residual tumor in purple after the 5-ALA. B) The operative bed without the dye*
25	*A) The operative field before injection of the sodium fluorescence dye. B) Fluorescence of the tumor after injection of the dye*
26	*It shows different effect of the electromagnetic field on the crystals, which may cause either expansion or shrinkage depending on the state of alternating current*
27	*It shows how the rays are generated in divergent way from the crystals. It needs lens to collect these rays together. A) The sound waves emitted from the crystal in all directions. B) The*

	lens, which bundle the rays to the focal point
28	*MRI image correlated to the IOUS image for detecting of normal brain anatomy and pathology*
29	*A) Example of a well-localized and well-defined lesion. B) Example of fairly localized and fairly defined lesion by the IOUS. C) Example of poorly localized and undefined lesion.D) IOUS image of epidermiod case.*
30	*Main surgeon oriented questionnaire*
31	*The ultrasound probe draped in the sterile drape A) microconvex probe. B) Linear probe. C) The IOUS device. D) Operative setting*
32	*A) The position of the head in prone position with flexion. B) Diagram of sitting position with air fluid (yellow color) level in the resection cavity, which provides a lot of ultrasound artifacts. C) Prone position of the head with fluid filling the cavity (yellow color)*
33	*A) Skin incision mark. B) Intraoperative picture after skin incision, showing muscle layer. C) Bony exposure after opening of the muscles. D) Island of bone on the occipital sinus. E) Dural exposure. F & G) IOUS applied to the dura with saline for localization of the lesion. H) Exposure of the cerebellum and the tumor. I) IOUS applied to the cerebellum and vermis to detect best corridor to the lesion.*
34	*A & B) localization of the lesion and measuring of the dimensions in the axial and sagittal orientation (arrow for lesion degeneration) C) Differentiate solid and cystic parts (red arrow for solid part and blue arrow for cystic part) D) Color flow mode.*
35	*A) Axial MRI T1WI with contrast with the residual two dimensions. B) IOUS image axial cuts with two dimensions measured. C) Sagittal MRI T1WI with contrast with the residual dimension.* D) IOUS sagittal with the residual dimension.
36	*A) IOUS scan showing the resection cavity (2 blue arrows and the brainstem (red arrow) B) Intraoperative view of the IOUS probe at the end of resection C) Intraoperative view of the floor of the fourth ventricle after resection of the tumor. D) Intraoperative view after dural closure.*

<u>List of tables:</u>

List of abbreviation:

Abbreviation	**Description**
5-ALA	*5 aminolevulinic acid*
AKA	*Also known as*
CBV	*Cerebral blood volume*
CN	*Cranial nerve*
CNS	*Central nervous system*
CPPRH	*Canadian Preoperative Prediction Rule for Hydrocephalus*
CSF	*Cerebrospinal fluid*
CT	*Computerized tomography*
ETV	*Endoscopic third ventriculostomy*
EVD	*External ventricular drainage*
ICP	*Intracranial pressure*
iCT	*Intraoperative computerized tomography*
iMRI	*Intraoperative magnetic resonance imaging*
IOUS	*Intraoperative ultrasound*
IRB	*Institutional review board*
KPS	*Karnofsky performance scale*
LPS	*Lansky performance scale*
MRI	*Magnetic resonance imaging*
REC	*Research ethics committee*
SD	*Standard deviation*
SEM	*Standard error of the mean*
US	*Ultrasound*
V-P Shunt	*Ventriculo-peritoneal shunt*
VHL	*Von Hipple-lindau*
WHO	*World health organization*

Background:

Posterior fossa lesions are considered as critical brain lesions. [231] This can be explained by the limited space of the posterior fossa and high risk of involvement of vital centers. [231] Surgical intervention of such lesions is considered of the top neurosurgical challenges. [231]

Posterior fossa lesions are more common in children than the adults. Between 54% and 70% of all childhood brain lesions originate in the posterior fossa [151].

Common types of posterior fossa lesions include the following:

- Primary neuroectodermal tumors, as: medulloblastomas, medulloepitheliomas, pigmented medulloblastomas, pineoblastomas, and cerebellar neuroblastomas. PNETs are second to the cerebellar astrocytoma in frequency, comprising 25% of intracranial tumors in children.
- Astrocytomas and hemangioblastomas
- Other common types include: metastatic tumors, hemangioblastoma, epidermiod tumors, and ependymal tumors.
- Other relatively rare include: Choroid plexus papilloma and carcinoma [196].

Neuronavigation provides the neurosurgeon with the ability to localize the lesion accurately, measure the lesion size, and to adjust surgical approach to the lesion. Currently available systems are both frame-based and frameless systems.

They are based on different localizing techniques, which include different types of optical pointers and electromagnetic systems.

All these image-guided systems are dependent on images acquired preoperatively. None of these systems can provide surgeons with real time information about intraoperative changes caused by brain shift.[79,137,172]

Recently, intraoperative MRI (iMRI) was introduced as a revolutionary solution defects of the neuronavigation systems. Although nowadays iMRI provides real time data for the neurosurgeon and aid in precise surgical updates it is relatively expensive, time consuming and space occupying device.[92,125,185,218]

In the early 1980s, *Rubin et al* published their first experience with the neurosurgical application of intraoperative ultrasound (IOUS).[29] They found that ultrasound is friendly to use and capable of demonstrating normal brain anatomy as well as identifying and localizing brain lesions. Since the 1990s, with the advance in imaging studies, real-time IOUS retained important role in neurosurgery for localization of subcortical lesions in eloquent brain areas.[29]

Real-time ultrasound may provide a much more economical device, which may provide sufficient data for the identification, localization of different brain pathologies in different areas. [48]

AIM OF WORK:

To evaluate the value of the use of intraoperative ultrasound (IOUS) in resection of intraaxial posterior fossa lesions as regards:

- Localization of tumor, delineation of tumor borders & differentiating solid and cystic parts.
- Real time intra-operative monitoring of tumor resection & detection of residual tumor dimensions.

(1)
Review of literature

1.1 Microsurgical anatomy:

1.1.1 Microsurgical Anatomy of the cerebellum

The posterior cranial fossa harbor one eighth of the intracranial space and is considered the most complex fossa in the skull base. [102] It contains the most complex intracranial anatomical structures, which control consciousness, respiration, cardiovascular systems and motor and sensory pathways, in addition to controlling balance and gait. [60] Majority of the cranial nerves have segments within the posterior fossa.[119] The posterior fossa has a strategic location at the flow of the cerebrospinal fluid. It has also a complex relationship with the cerebellar and brainstem vessels. [109] These vessels runs a complex course in front of the brain stem and their branches have loops and courses between the cranial nerves before reaching the cerebellar surface.[66,109,116]

Extensions:

The posterior fossa communicates with the cerebrum and supratentorial space through the tentorial incisura.

It extends through the foramen magnum to the spinal canal.[117] It is surrounded by the occipital, temporal, parietal, and sphenoid bones. The upper surface of the cerebellum is separated from the supra-tentorial space by the tentorium cerebelli.[168]

Surfaces:

The cerebellar surfaces are divided into: Tentorial, Suboccipital and petrosal surfaces. [168]

Suboccipital surface: *Fig 1*

It is considered the most complex surface and it is the most commonly surface exposed during surgical approaches to the fourth ventricle and cerebellar tumors. This surface is enclosed between the lateral and sigmoid sinus.[169]

Topographic description of this surface shows a deep vertical depression, which is the posterior cerebellar incisura; it contains the falx cerebelli. The cortical surface of the incisura is formed by the vermis, however the medial walls of the cerebellar hemispheres form the lateral walls. The vermis is separated from the hemispheres by a deep fissure.[168]

Viewing the vermian part of the suboccipital surface it appears as a diamond shape divided into two halves. The upper half is the pyramid. The lower half is the uvula projecting downwards between the tonsils. The lower most part of the vermis hidden deep to the uvula is the nodule. Inferiorly, the posterior cerebellar incisura is continuous with the vallecula cerebelli, which is a cleft between the tonsils leading to the foramen of Magendie and the fourth ventricle.[168]

From above to below the folium and the superior semilunar lobules, the tuber and the inferior semilunar lobules, the pyramid and the biventral lobules, and the uvula and the tonsils form the divisions of the suboccipital surface. The major fissure of the suboccipital surface divides it into superior part (including tuber and the biventral lobe) and inferior part including the pyramid and semilunar lobules. The petrosal fissure, which is the major fissure on the petrosal surface, it separates the superior and inferior semilunar lobules on the lateral side and the folium and the tuber on the medial side. A fissure called the tonsillobiventral fissure is separating the tonsil from the biventral lobule.[168]

An access to the fourth ventricle from the suboccipital surface is in between the cerebellar tonsils below the uvula through what is called the vallecula. These tonsils are ovoid in shape and are a hemispheric component. Each tonsil is attached to the cerebellar hemisphere through a tonsillar peduncle (a white matter connection bundle). The cisterna magna is related to the posterior pole of the tonsils.

Fig 1: *A) Suboccipital* surface of the cerebellum showing vermian and cerebellar *parts. B)* It shows the vallecula (blue arrow) and access to fourth ventricle[127]