Stereotactic brain biopsy case series

A retrospective analysis was performed on 50 consecutive patients who underwent stereotactic brain biopsies in the Department of Neurosurgery, Sarawak General Hospital, Ministry of Health, Jalan Hospital, 93586, Kuching, Sarawak, Malaysia from 2014 to 2019. Variables including age, gender, lesion topography and characteristics, biopsy methods, and surgeon's experience were analyzed along with diagnostic rate. This study included 31 male and 19 female patients with a mean age of 48.4 (range: 1-76). Of these, 25 underwent frameless brain-suite stereotactic biopsies, 15 were frameless Portable Brain-lab® stereotactic biopsies and 10 were frame-based CRW® stereotactic biopsies. There was no statistical difference between the diagnostic yield of the three methods. The diagnostic yield in our series was 76%. Age, gender, and biopsy methods had no impact on diagnostic yield. Periventricular and pineal lesion biopsies were significantly associated with negative diagnostic yield ($p = 0.01$) whereas larger lesions were significantly associated with a positive yield ($p = 0.01$) with the mean volume of lesions in the positive yield group (13.6 cc) being higher than the negative yield group (7 cc). The diagnostic yields seen between senior and junior neurosurgeons in the biopsy procedure were 95% and 63%, respectively ($p = 0.02$). Anatomical location of the lesion, volume of the lesion, and experience of the surgeon have significant impacts on the diagnostic yield in stereotactic brain biopsy. There was no statistical difference between the diagnostic yield of the three methods, age, gender, and depth of lesion [1)].

2019

A retrospective cohort study was conducted of all adult patients with imaging-documented lesions undergoing FSB at the Beth Israel Deaconess Medical Center between 2013-2018. Diagnostic accuracy, lesion characteristics associated with non-diagnostic biopsy, and surgical complications were evaluated. A biopsy was considered non-diagnostic if all frozen samples and the final pathology yielded normal brain tissue or non-specific reactive tissue unless the “reactive” pathology was consistent with radiation injury from prior therapy.

This search identified 198 FSB patients. Mean (SD) age was 62±17 years and 44.2% were female. The median procedure time was 32 minutes. A definitive histologic diagnosis was established in 187 cases (94.4% diagnostic yield). The mean lesion diameter was 31.9±16.8 mm. Multivariable logistic regression revealed only lesion diameter to be significantly associated with a diagnostic result (OR for the non-diagnostic result: 0.94 per mm diameter decrease, 95% CI 0.87-0.99, P=0.028). On univariable analysis, the diagnosis of CNS lymphoma appeared to increase the risk of a non-diagnostic biopsy (P=0.025), but this association disappeared when controlling for lesion size and steroid administration prior to biopsy. Eight patients (4.0%) developed postoperative hemorrhagic complications, three of whom required reoperation, and another expired.

This study demonstrates that diagnostic yield from contemporary FSB is high and is dependent predominantly on lesion size. [2)].

Hamisch et al. evaluated the feasibility, safety, and diagnostic yield of frame-based stereotactic biopsies (SB) in lesions located in deep-seated and midline structures of the brain to analyze these parameters in comparison to other brain areas.

In a retrospective, tertiary care single-center analysis, they identified all patients who received SB for lesions localized in deep-seated and midline structures (corpus callosum, basal ganglia, pineal region, sella, thalamus, and brainstem) between January 1996 and June 2015. Study participants were between 1 and 82 years. We evaluated the feasibility, procedural complications (mortality, transient and permanent morbidity), and diagnostic yield. We further performed a risk analysis of factors influencing the latter parameters. Chi-square test, Student t test, and Mann-Whitney rank-sum test were used for statistical analysis.

Four hundred eighty-nine patients receiving 511 SB procedures (median age 48.5 years, range 1-82; median Karnofsky Performance Score 80%, range 50-100%, 43.8% female/56.2% male) were identified. Lesions were localized in the corpus callosum (29.5%), basal ganglia (17.0%), pineal region (11.5%), sella (7.8%), thalamus (4.3%), brainstem (28.8%), and others (1.1%). Procedure-related mortality was 0%, and permanent morbidity was 0.4%. Transient morbidity was 9.6%. Histological diagnosis was possible in 99.2% (low-grade gliomas 16.2%, high-grade gliomas 40.3%, other tumors in 27.8%, no neoplastic lesions 14.5%, no definitive histological diagnosis 0.8%). Only the pons location correlated significantly with transient morbidity ($p < 0.001$).

In experienced centers, frame-based stereotactic biopsy is a safe diagnostic tool with a high diagnostic yield also for deep-seated and midline lesions [3].

A retrospective study of Department of Neurosurgery, Son Espases University Hospital and University Hospital of Salamanca, evaluated 407 patients who underwent stereotactic biopsies in the past 34 years. The surgical methodology changed through time, distinguished by three distinct periods. Different stereotactic frames (Todd-Wells, CRW, Leksell), neuroimaging tests, and planning programs were used. Using SPSS software v.23, we analyzed a total of 50 variables for each case.

The series included 265 men (65.1%) and 142 women (34.9%) (average age 53.8 years). The diagnostic yield was 90.4%, morbidity was 5.65% ($n = 17$), and mortality was 0.98% ($n = 4$). Intraoperative biopsy improved accuracy ($p = 0.024$). Biopsies of deep lesions ($p = 0.043$), without contrast enhancement ($p = 0.004$), edema ($p = 0.036$), extensive necrosis ($p = 0.028$), or a large cystic component ($p = 0.023$) resulted in a worse diagnostic yield. Neurosurgeons inexperienced in stereotactic techniques obtained more nondiagnostic biopsies ($p = 0.043$). Experience was the clearest predictive factor of diagnostic yield (odds ratio: 4.049).

Increased experience in stereotactic techniques, use of the most suitable magnetic resonance imaging sequences during biopsy planning, and intraoperative evaluation of the sample before finalizing the collection are recommended features and ways to improve the diagnostic yield of this technique [4].

2018

500 consecutive Frame-based stereotactic biopsy (FBSB) using iMRI were compared to a historic control of 100 biopsies with traditional workflows (computed tomography (CT) with MRI image fusion). All procedures were performed under general anesthesia. Data on surgical procedures, pre- and postoperative neurologic patient status, complications and diagnostic yield were extracted from clinical records.

Complication rates and diagnostic yield showed no significant differences between both groups. Mortality was 0.6%, 95% CI = [0.12%, 1.74%], in the iMRI and 0.0% [0.00%, 3.62%], in the control group with a morbidity of 5.4% [3.6%, 7.8%] and 6.0% [2.2%, 12.6%] and a diagnostic yield of 96.8% [94.9%, 98.2%] and 96.0% [90.1%, 98.9%]. Mean procedure duration was 124 [121, 127] minutes using iMRI and 112 [106, 118] minutes in the control group.

FBSB using 1.5T iMRI under general anesthesia is a safe and effective procedure and is equivalent to traditional stereotactic workflows with respect to complication rate and diagnostic yield [5].

Twenty-one patients referred for surgery for MRI features concerning for tumor progression versus treatment effect underwent pre-operative APTw imaging. Stereotactic biopsies were taken from regions of interest with varying APTw signal intensities. The relationship between final clinical pathology as well as the histopathology of each of the 64 specimens was analyzed relative to APTw results. Analysis of confirmed recurrent tumor or treatment effect tissue was used to perform receiver-operating-characteristic (ROC) analysis.

Eighteen of 21 patients had recurrent tumor, and 3 had treatment effect on clinical pathology. In 12 patients, there were multiple histopathologic assignments confirmed within the same tumor. Of the 64 total specimens, 20 specimens were active glioma, 27 mixed active and quiescent glioma, and 17 quiescent/no identifiable tumor. APTw signal intensity and histopathologic assignment, cellularity, and proliferation index had significant positive correlations ($R = 0.651$, 0.580, and 0.458, respectively; all $P < 0.001$). ROC analysis with a 1.79% APTw intensity cutoff differentiated active from non-active tumor (AUC of 0.881) with 85.1% sensitivity and 94.1% specificity. Analysis of clinical pathology showed the mean APTw intensity for each patient had 94.4% sensitivity and 100% positive predictive value for identifying recurrent glioma at this cutoff.

APTw imaging hyperintensity may be a marker of active malignant glioma. It is able to distinguish between regions of heterogeneous abnormality on anatomical brain MRI with high sensitivity and specificity [6].

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de Quintana-Schmidt et al. documented 30 stereotactic brain biopsies. 3 (10%) of these cases had intractable surgical bed bleeding during the procedure. In all 3 cases, thrombin-gelatin matrix was injected and an immediate arrest was achieved. Neither of the patients required a craniotomy or further invasive measure to achieve the hemostasis. No postoperative complications were recorded.

The preliminary results suggest that the thrombin-gelatin matrix injection is a simple, safe and effective stereotactic practice to manage persistent surgical bed bleeding that cannot be arrested by standard, conventional hemostatic methods [7].

In a cross-sectional study conducted among 80 patients who underwent computed tomography guided frame based stereotactic biopsy during a period of 6 years. All operations were performed under local anesthesia. Histopathology reports were retrieved and accuracy of biopsy technique analyzed.

Out of 80 patients, 58 were male with male to female ratio of 2.6:1. Median age of patients were 50 years with range from 16 to 75 years. Most lesions were in deeper location 49 (61.3%). Most common

location was Parietal, 15 (18.8%) followed by Thalamic, 12 (15%). Mean size of lesion was 2.88±0.71cms ranged from 2 to 5cms. Biopsy was accurate to retrieve target in 74 (92.5%) patients. Histopathology revealed glial tumor in 41 (51.2%) of cases. Overall morbidity was observed in 3 (5.5%) patients. There is no procedure related mortality in this study during study period.

Frame based biopsy of intracranial space occupying lesion is safe and efficacious procedure with high diagnostic yield [8)]

Callovini et al. from the Department of Neurosurgery, San Giovanni-Addolorata Hospital, IRCCS Regina Elena National Cancer Institute, San Filippo Neri Hospital, Rome, Italy, analyzed a series of 421 SBB cases treated between January 2002 and June 2017 in three major neurosurgical institutes in Rome, serving a total of 1.5 million people. Within this series, 94.8% of patients underwent FBB, while, more recently, FLB was performed in 5.2% of cases. The entire period under consideration, running from 2002 to 2017, has been further stratified into four-year time-frames (2002-2005, 2006-2009, 2010-2013, 2014-2017) for the purpose of analysis.

The diagnostic yield was 97%. Final diagnoses revealed tumors in 90% of cases and non-neoplastic masses in 7%, while 3% of cases were not conclusive. The morbidity rate was 3% (12 cases) and mortality was 0.7% (3 cases). Intra-operative frozen sections were made in 78% of biopsies. In our three institutes, the number of SBBs decreased steadily throughout the time-frames under consideration. We have also observed a statistically significant reduction in biopsy procedures in lobar lesions, while those performed on the basal ganglia increased and the number of SBBs of multiple masses and lesions of the corpus callosum remained stable. Primary central nervous system diagnosis of lymphomas (PCNSL) was the sole diagnosis whose incidence increased significantly.

Over the last sixteen years, they have witnessed a significant decrease in SBB procedures and a modification in target selection and histologic results. Despite the significant evolution of neuroimaging, an accurate non-invasive diagnosis of intracranial expanding lesions has not yet been achieved. Furthermore, the most recent WHO classification of brain tumors (2016), which incorporates molecular and morphological features, has boosted the need for molecular processing of tissue samples in all expanding brain lesions. For these reasons, it is likely that SBBs will continue to be performed in specific cases, playing a significant role in diagnostic confirmation by providing tissue samples, so as to better assess the biology and the prognosis of cerebral lesions, as well as their sensitivity to standard radio-chemotherapy or to new molecular target therapies [9)].

This prospective cohort study enrolled 56 adult patients: (1) for whom no conclusive diagnosis could be reached noninvasively; (2a) who had lesions involving deep-seated and eloquent areas, multifocal lesions, or lesions for which craniotomy and lesion removal was not indicated, or (2b) were poor candidates for craniotomy (> 80 years of age and/or with serious comorbidities). Frameless and frame-based biopsy were performed in 28 patients each RESULTS: A diagnosis was not made in four cases (14.3%) of the frame-based biopsy group and in three cases (10.7%) of the frameless biopsy group, in spite of accurate targeting ($p = 1.0$). The mean duration of the whole procedure (preparatory steps outside the operating room [OR], inside the OR, surgery) was 111.3 minutes for the frame-based biopsy and 79.1 minutes for the frameless biopsy ($p = 0.001$). No statistically significant differences between the two methods were found concerning new neurologic symptoms, new abnormal findings in postoperative computed tomography (CT) and length of postoperative hospital

stay (LOS). The smallest diameter of a successfully biopsied lesion was 15 mm for both groups.

The frameless fiducial-less brain biopsy was equally efficacious and safe compared with the standard stereotactic frame-based biopsy. The overall duration of frameless biopsy is shorter than that of frame-based biopsy, mainly because the preparatory steps in frameless biopsy require less time. However, the overall time spent in the OR did not differ between the two groups. The LOS also did not differ significantly [10].

2015

Grand Challenge Veterinary Neurology and Neurosurgery: Veterinary Neurology and Neurosurgery - Research for Animals and Translational Aspects [11].

A report described the methodology, diagnostic yield, and adverse events (AE) associated with frame-based stereotactic brain biopsies (FBSB) obtained from 26 dogs with solitary forebrain lesions. Medical records were reviewed from dogs that underwent FBSB using two stereotactic headframes designed for use in small animals and compatible with computed tomographic (CT) and magnetic resonance (MR) imaging. Stereotactic plans were generated from MR and CT images using commercial software, and FBSB performed both with (14/26) and without intraoperative image guidance. Records were reviewed for diagnostic yield, defined as the proportion of biopsies producing a specific neuropathological diagnosis, AE associated with FBSB, and risk factors for the development of AE. Postprocedural AE were evaluated in 19/26 dogs that did not proceed to a therapeutic intervention immediately following biopsy. Biopsy targets included intra-axial telencephalic masses (24/26), one intra-axial diencephalic mass, and one extra-axial parasellar mass. The median target volume was 1.99 cm(3). No differences in patient, lesion, or outcome variables were observed between the two headframe systems used or between FBSB performed with or without intraoperative CT guidance. The diagnostic yield of FBSB was 94.6%. Needle placement error was a significant risk factor associated with procurement of non-diagnostic biopsy specimens. Gliomas were diagnosed in 24/26 dogs, and meningioma and granulomatous meningoencephalitis in 1 dog each. AE directly related to FBSB were observed in a total of 7/26 (27%) of dogs. Biopsy-associated clinical morbidity, manifesting as seizures and transient neurological deterioration, occurred in 3/19 (16%) of dogs. The case fatality rate was 5.2% (1/19 dogs), with death attributable to intracranial hemorrhage. FBSB using the described apparatus was relatively safe and effective at providing neuropathological diagnoses in dogs with focal forebrain lesions [12].

Seventy-six brain biopsies in 75 consecutive patients (51 closed and 25 open) were analysed. Diagnostic yield was 98% for closed biopsies and 96% for open biopsies. Mortality related to the procedures was 3.9 and 4%, respectively. The incidence of major complications was 3.9% for closed biopsies and 8% for open biopsies; half of these appeared within the first 24 postoperative hours, during patient stay in the Intensive Care Unit. Age was the only risk factor for complications (P=.04) in our study. No differences in morbimortality were found between the studied groups

Diagnostic yield was very high in our series. Because the importance of early diagnosis of complications for preventing long-term sequelae, we recommend overnight hospital stay for

observation after open or closed brain biopsy [13].

2014

A retrospective analysis of all frame-based and frameless stereotactic biopsies carried out over 57 months from July 2006 to March 2011. Results. A total of 351 biopsies were undertaken, 256 frame-based (73%) and 95 frameless (27%). Mean age was 57 years (range 18-87). Negative biopsy rate was 5.1%. There was a significantly greater negative biopsy rate in deep brain biopsies ($p = 0.011$) and in the cerebellum ($p < 0.001$). Intra-operative smear significantly reduced negative biopsy rates from 11.1% to 3.7% ($p = 0.011$). If repeat smear was requested, yet not provided, then the negative biopsy rate was 57.1% ($p = 0.0085$). The overall symptomatic haemorrhage rate was 3.7%. There was a significant increase in haemorrhage rate in deep versus superficial biopsies ($p = 0.023$) and a significantly greater haemorrhage rate in lymphoma biopsies ($p = 0.015$). There was no significant increase in haemorrhage rate in high-grade- compared with low-grade tumour biopsies. Mortality rates at 7 and 30 days post-operatively were 0.6% and 1.7%, respectively, with mortality after 7 days unrelated to biopsy [14].

2008

During a 28-year interval, we performed frame-based stereotactic surgery in 2,651 patients. Our database was retrospectively used to assess the risks of complications after frame-based stereotactic surgery. Routine immediate intraoperative imaging detected new blood products after diagnostic biopsy in 43 cases (2.6%); only 6 patients (0.36%) required craniotomy for hematoma evacuation. Perioperative seizures occurred in 6 patients (0.36%), and 2 patients developed burr hole site infections. One patient (1%) developed an intra-abscess hemorrhage after biopsy and catheter drainage. Two deaths (0.08%) related to surgery occurred. Some centers are currently migrating to frameless, even pinless, neuronavigation-guided needle procedures for both lobar and deep brain targets. Although experimental accuracy under optimal conditions is reported to be similar to that of frame-based systems, the complication rates from a significant number of cases have yet to be reported. This report establishes the safety profile of frame-based stereotactic surgery based on a 28-year period. These results may serve as a benchmark against which free-hand or guided neuronavigation approaches may be measured, as both the advantages and risks of such procedures are assessed [15].

2005

Medical and radiological records of 355 consecutive patients who underwent a diagnostic stereotactic brain biopsy were reviewed. The incidence of haemorrhage was derived from a routine post-operative CT scan done within 90-120 minutes of the biopsy. Demographic, radiographic, pathological, and clinical data were also extracted and evaluated for their possible association with haemorrhagic complications.

Twenty-five patients (7%) experienced haemorrhagic complications associated with stereotactic biopsy, about half of whom (3.4%) were asymptomatic with no impact on the clinical course. Thirteen

(3.6%) complications were symptomatic and two patients (0.6%) died. Lesions located in the brainstem were found to have a significantly higher rate of complications compared to other locations. No other variables, such as location, edema, number of biopsy specimens, or pre-existing neurological deficit showed a statistically significant impact on the incidence or severity of haemorrhage. Seven of the symptomatic complications occurred immediately post biopsy, but in six patients they developed within several hours and even days. The overall diagnostic yield of the biopsies was 93.8%, but was somewhat lower in patients experiencing a haemorrhagic complication.

Stereotactic brain biopsy was associated with a low incidence of symptomatic haemorrhagic complications, morbidity and mortality, and a high diagnostic yield. About half of the haemorrhagic complications were asymptomatic. Lesions located in the brainstem had a higher rate of complications. No other clinical, radiographic, or pathological variables were found as predictors of increased risk for haemorrhage [16].

2002

The frameless and frame-based series were concurrent, comprising 76 and 79 cases, respectively. The frameless stereotactic technique involved standard needle biopsy, targeted by an image-guidance system and directed by a novel rigid adjustable instrument-holder. Frame-based biopsies were performed with the CRW and Leksell systems. There were no significant differences in the demographics, lesion site, size and pathologies between the groups. Operating theatre occupancy and anaesthetic time were both significantly shorter for the frameless series than the frame-based series ($p < 0.0001$). In addition, the complication rate in the frameless biopsy series was significantly lower than in the frame-based series ($p = 0.018$). This resulted in lower ITU bed occupancy ($p = 0.02$), shorter mean hospital stay ($p = 0.0013$) and significant cost savings ($p = 0.0022$) for the frameless stereotactic biopsy group, despite the greater use of more expensive MRI in these cases. This comparison study demonstrates that the superior imaging, target visualization and flexibility of the technique of frameless stereotactic biopsy translates into tangible advantages for safety, time and cost when compared with the current gold-standard of frame-based biopsy. The principles are discussed and the authors propose a definition for the term 'frameless stereotaxy' [17].

1989

Chandrasoma et al. report the pathological accuracy of image-directed stereotactic brain biopsy in 30 patients who had mass lesions of the brain and subsequently underwent resection of the mass. The histological diagnosis at stereotactic biopsy was appropriate for direction of clinical management in 28 of 30 patients. Correlation between the stereotactic and resection diagnoses was exact in 19 of 30 cases. These included 11 of 12 nonastrocytic neoplasms and 8 of 13 astrocytic neoplasms. Correlation was imperfect in 9 of 30 cases, but not to the extent of having significant clinical impact. These included 2 cases of anaplastic astrocytoma that were upgraded to glioblastoma multiforme, 2 cases of astrocytoma that had a significant oligodendroglial component, and 5 non-neoplastic lesions that were reported on biopsy as showing nonspecific reactive changes. In 2 of 30 patients, the stereotactic biopsy was not accurate. This included one patient who had glioblastoma multiforme whose stereotactic biopsy showed only necrotic tissue. Serious diagnostic error that resulted in clinical mismanagement occurred in one patient who had a pineal germinoma that had large areas of granulomatous inflammation at which the stereotactic biopsy was directed. This study provides evidence that, with careful target placement, stereotactic biopsy can provide biopsy material that

represents the entire lesion with an accuracy that is sufficient for clinical management [18].

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