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CEREBRAL BIOPSY

Comparison between frame-based stereotaxy and neuronavigation in an oncology center

Carlos Augusto Ferreira Lobão[1], Janio Nogueira[1], Antonio Aversa Dutra do Souto[2], José Antonio de Oliveira[1]

Abstract – Treatment of intracranial tumoral lesions is related to its correct histological diagnostic. We present a retrospective analysis of 32 patients submitted to 36 cerebral biopsies using neuronavigation and 44 patients using frame-based stereotaxy. Mean age was 46.6 and 49.3 years old respectively. Sex distribution in both groups was 50% for each. Most of lesions were lobar in both groups. Diagnostic yielding was 91.7% and 83.4%, respectively (p=0.26). We found in the postoperative CT scans intracranial hemorrhages in 13.8% cases of the first group and 9.8% cases in the second. Most of them were mild post-operative hemorrages in the biopsy site. There was one death related to the procedure in each group. Astrocytomas and metastatic adenocarcinomas were the most frequent diagnosis. Diagnostic yielding and the number of postoperative hemorrhage and death were similar on both groups and the same found in the literature.

KEY WORDS: brain tumor, neuronavigation, stereotaxy.

Biópsia cerebral: comparação entre estereotaxia com arco e neuronavegação em um centro de oncologia

Resumo – O manejo das lesões intracranianas tumorais está relacionado ao seu diagnóstico histológico adequado. Foi realizado estudo retrospectivo com 32 pacientes submetidos a 36 biópsias cerebrais por neuronavegação e 44 pacientes por estereotaxia com arco. A idade média foi 46,6 e 49,3 anos respectivamente. Nos dois grupos a distribuição por sexo foi 50% para cada. A maioria das lesões biopsiadas eram lobares nos dois grupos. A positividade diagnóstica foi 91,7% para neuronavegação e 83,4% para a estereotaxia com arco, respectivamente (p=0,26). Identificou-se hemorragia intracraniana na TC pós-operatória em 13,8% dos casos no primeiro grupo e em 9,8% no segundo, a maioria de pequena monta sem provocar piora neurológica. Ocorreu uma morte relacionada ao procedimento em cada grupo. Os diagnósticos mais freqüentes foram astrocitomas e adenocarcinomas metastáticos. A positividade diagnóstica, taxas de hemorragia pós-operatória e de mortalidade foram equiparáveis estatisticamente entre os dois métodos e se assemelham com as descritas na literatura.

PALAVRAS-CHAVE: tumor cerebral, neuronavegação, estereotaxia.

Treatment of intracranial mass lesions is highly reliant in its correct histological diagnosis. Treatment based only on clinical and radiological aspects is unsuccessful in one third of cases even using modern diagnostic techniques[1,2]. Advances on stereotactic techniques and more recently on image guided surgery or neuronavigation have left empirical treatment of intracranial tumors, without histological confirmation, to be exceptions[3]. Nowadays the concept of minimally invasive surgery is becoming a daily reality in modern neurosurgery[4]. Among the advantages of this kind of surgery we can list smaller and more precise approaches, lower surgical time, less damage to eloquent structures, and, as a consequence, smaller morbidity and infection rates, and hospital staying[5,6]. Navigation means, by definition, orientation in space. On medical settings we consider it as the orientation on a given anatomical volume[7]. Image guided surgery is the use of preoperative images previously transferred to a computer for sur-

[1]Neurocirurgião, Instituto Nacional de Câncer (INCA), Rio de Janeiro RJ, Brazil; [2]Neurocirurgião, Instituto Nacional de Câncer (INCA) e Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro RJ, Brazil.

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Dr. Carlos Augusto Ferreira Lobão – Vila Dona Maria Leopoldina 236 - 66060-180 Belém PA - Brasil. E-mail: caflobao@yahoo.com.br

gical guidance during surgery[8]. It enables the surgeon to make 3D localization of a lesion, program surgical trajectory, and localize anatomical structures and surgical instruments at real time[9]. The technique evolved during the 80´s permits a more accurate preoperative planning with smaller and more precise approaches[10]. Knowing the exact location of important and eloquent intracranial structures makes its preservation more likely and permits the surgeon a better resection control[11]. Many evidences suggest that neuronavigation reduces costs when compared it to standard localization procedures[6,12]. On the other hand, frame-based stereotactic biopsy was the gold standard for acquiring intracranial samples for a long time[13-15]. The morbidity rate associated to frameless stereotaxy is 0 to 27%[13,16,17], mortality rate ranges from 0 to 9%[18], and the diagnostic yielding is 79 to 100%[16,19].

With the advent of neuronavigation the use of frame-based biopsy is becoming smaller because image guided biopsies offers many advantages, like: (1) more comfort to the patient without the using of the stereotactic frame[20]; (2) good diagnostic yielding and few complications[11,21]; (3) the surgical instruments used on neuronavigation occupies less place related to the stereotactic frame applied to the patient head[22]; (4) the trajectory of the biopsy needle can be changed any time during the surgery without new calculations[23,24]; (5) quicker surgical times[23]. Taking these advantages in consideration it is easy to realize why neuronavigation reached such a great importance in actual neurosurgery. Chiefly in neurooncology services, neuronavigation became a very useful tool with many applications in the treatment of intracranial neoplasm.

The objective of this study is to present the experience of the Oncologic Neurosurgery Service of the National Institute of Cancer in Brazil with frameless cerebral biopsies and to make a comparison with the frame-based method analyzing diagnostic yielding, postoperative hemorrhage, and mortality, related to the two procedures.

METHOD

Patients selection

All patients were treated at the Neurosurgery Service of the National Institute of Cancer in Bazil from 2004 to 2007. We did a retrospective analysis of two groups: one group of patients was submitted to frameless cerebral biopsies (neuronavigation), and in the other group frame-based cerebral biopsies were used. The first group was composed of 32 patients with the mean age of 46.6 years-old, ranging from 8 to 80 years-old, were 36 biopsies were performed on. The second group of 44 patients with the mean age of 49.3 years-old, (3–77 years-old) had 51 frame-based procedures carried out. Half of the patients in each group was composed of male patients.

Surgery was performed by the members of neurosurgery staff of the service for getting the correct diagnosis of varied intracranial mass lesions. Hospital staying considered the time necessary for any procedures related to treatment, not only the biopsies. Immediate pos-operative CT scans were performed in the 32 patients (88,8%). Criteria for performing the immediate post-operative CT scans were not strictly adopted and were considered at an individual basis. The main reasons to indicate the CT scans were a small bleeding through the biopsy needle occurred, or patients exhibiting post-operative neurological deterioration.

Patients provided informed consent agreeing with data publication and the study was accepted by the Ethic Committee of the National Institute of Cancer - Brazil.

Frameless cerebral biopsy

Roughly seventy 1.5 Tesla T1-weighted gadolinium enhanced axial MRI images were transferred to the neuronavigation workstation preoperatively and the software Cranial Planning v. 1.2 (BrainLAB AG, Heimstetten, Alemanha) was used. This interface helped to establish the exact surgical target, entry point, and surgical trajectory, avoiding vital structures and through the safer way. Choosing the surgical target was based in many factors mainly as the most enhancing point of the lesion or the center of a hipointense mass. Proximity of vascular structures and very eloquent areas were avoided. After that planning, the data were transferred to the BrainLab VectorVision Compact neuronavigator (BrainLAB AG, Heimstetten, Alemanha).

Depending on the pre-operative patient consciousness level we have chosen among general or local anesthesia with sedation. Head was fixed with the three-points Mayfield head-holder in which we adapted a device with infrared reflexive spheres for recognition with the neuronavigator. It was used a Sedan-Nashold biopsy needle with reflexive spheres attached to it. Forehead and facial surface anatomical landmarks were obtained with the laser pointer scanner. Minimal accepted registration error was 2 mm. Whenever a bigger estimated error was considered, a new registration process was performed. Biopsy needle was calibrated and recognized by the neuronavigation software in relation to the head position and inserted based on three-planar images generated by the neuronavigator (Fig 1A,B). The number of the samples of tissue obtained and the decision to switch to a new target were considered according to the per-operative neuropathologist smear hystological analysis of the samples. The software used for neuronavigation was Cranial Navigation v. 6.0 (BrainLAB AG, Heimstetten, Alemanha).

Frame-based cerebral biopsy

Frame-based cerebral biopsy is a well-known and standardized technique[7,10]. Moments before the surgery an ETM03-B stereotactic frame (Micromar, Diadema, SP) was fixed to the patient head, and a contrast-enhanced CT-scan performed for x, y, and z target coordinates determination. In case of patient confusion and altered states of consciousness general anesthesia was performed. Biopsy needle attached to the stereotactic frame was inserted to the target defined by the coordinates. Surgical tar-

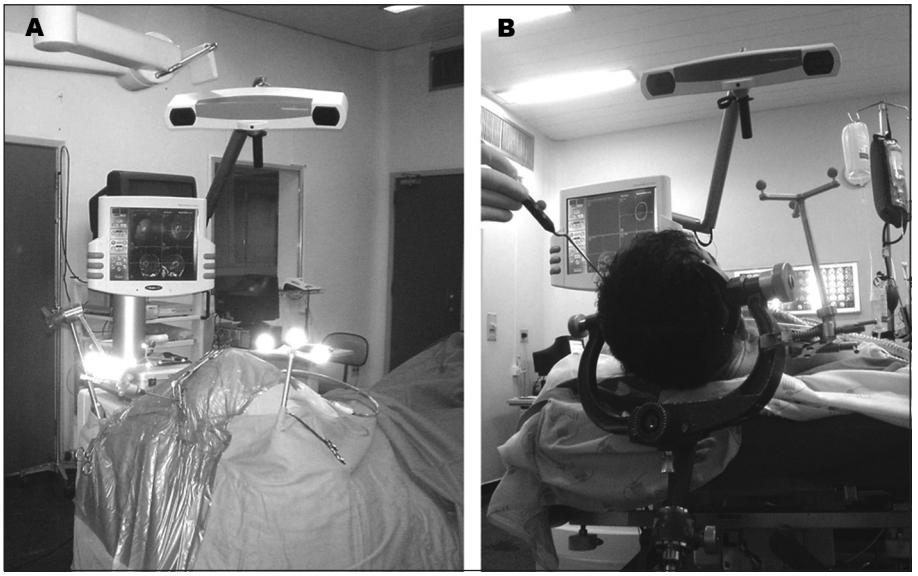

Fig 1. [A e B] Neuronavigation antenna pointed to the star-shaped tool fixed to three points Mayfield head-holder. There most be no obstacles between the antenna and reflexive spheres attached to surgical instruments.

Table 1. Frequencies, percentiles, and χ^2-test (qui-square).

	Neuronavigation		Frame-base stereotaxy		
	n	%	n	%	χ^2-test
Year studied					
2004	1	3.0	12	23.5	
2005	7	19.0	14	27.0	p=0.001
2006	14	39.0	24	47.5	
2007	14	39.0	1	2.0	
Gender					
Male	16	50.0	22	50.0	–
Female	16	50.0	22	50.0	
Lesion side					
Left	20	62.5	21	47.7	
Right	9	28.1	20	45.5	p=0.31
Midline	3	9.4	3	6.8	
Localization					
Lobar	22	68.8	31	70.5	
Basal nucleus	5	15.6	9	20.4	p=0.25
Dien/Mes	3	9.4	3	6.8	
Pineal	2	6.2	1	2.3	

Dien/Mes: diencephalon and mesencephalon.

get was the most enhancing point of a lesion on CT-scan or the center of a hipodense mass. A new target point was calculated, and we chose a different trajectory in the case of inconclusive in-print analysis by the pathologist.

Statistical analysis

We performed non-parametric χ^2-test (qui-square test), considering significant $p<0.05$.

RESULTS

Table 1 shows data relative to both studied groups: group I, frameless cerebral biopsy, and group II, frame-based cerebral biopsy. We observed an increasing trend for using frameless biopsy throughout the time period studied. Both groups had a preponderance of lobar lesions biopsies, 68.8% and 70.5%, respectively. There was no significant difference between lesion localization on

Table 2. Post-operative hemorrhage and mortality related to stereotactic cerebral biopsies.

	Neuronavigation		Frame–based stereotaxy	
	n	%	n	%
PO hemorrhage	5	13.8	5	9.8
Small ICH	3	8.3	5	9.8
Small IVH	1	2.7	–	–
Huge ICH	1	2.7	–	–
Hypertensive oedema	–	–	1	1.9
Mortality	1	2.7	1	1.9

PO: post-operative; ICH: intra-cerebral hemorrhage; IVH: intra-ventricular hemorrhage.

Table 3. Histological diagnosis on stereotactic cerebral biopsies.

Histological diagnosis	Neuronavigation	Frame-based stereotaxy
Low grade astrocytoma (I and II)	11	14
High grade astrocytoma (III and IV)	10	17
Metastatic adenocarcinoma	4	4
Anaplasic oligodendroglioma	3	0
Non-Hodgkin linphoma	1	1
Demielinizating disease	1	0
Germinoma	1	0
Chronic inflammatory disease	1	0
Atypical craniopharingioma	0	1
Toxoplasmosis	0	1
Pineoblastoma	0	1
Oligodendroglioma	0	1
Total	32	40

each hemisphere or in the midline considering two groups (p=0.31).

Diagnostic yielding for frameless cerebral biopsy was 91.7%, and 83.4% for frame-based biopsies. This difference was not statistically significant (p=0.26, Fig 2). Considering non-diagnostic frame-based biopsies, seven were repeated using the same method, one was repeated with frameless stereotaxy, one patient was submitted to craniotomy for surgical tumor resection and open biopsy, and one patient had empirical corticoid treatment with lesion disappearance. Five out of seven non-diagnostic cases repeated with frame-based stereotaxy were diagnostic on second procedure, one case was considered and treated as a demializating disease, and one patient died before a new diagnosis attempt. Only four of the frameless biopsy procedures were not diagnostic. These cases were submitted to a second frameless procedure with positive diagnosis.

Mean hospital staying was 11.6 days for frame-based biopsies, and 15.9 days for frameless procedures. There was no significant difference between then (p>0.05).

We observed five post-operative intracranial hemorrhages on frameless biopsies group (13.8%) in the post-operative CT-scans. Three small volume cerebral hemorrhages on biopsy site, and one case of small third ventricle hemorrhage, all of then without clinical significance. Nevertheless there was one case of surgical treated cerebral hemorrhage that evolved to death.

Five cases of frame-based cerebral biopsies developed small post-operative cerebral hemorrhage at biopsy site (9.8%) observed in the post-operative CT-scans. One patient submitted to frame-based biopsy presented important clinical deterioration at PO day 1. CT-scan showed transtentorial herniation, sub-falcine herniation, herniation of the left uncus, and intense supratentorial edema at the lesion site. This patient was submitted to decompressive craniotomy immediately after diagnosis but evolved to death at PO day 4 (Table 2, Fig 2). There is no statistically significant difference among symptomatic and non-symptomatic post-operative intracranial hemorrhage and mortality comparing both groups (p>0.05).

Table 3 presents histological diagnosis at both groups studied. There is a clear predominance of low-grade and high-grade gliomas on both of then. There are four cases of frame-based biopsies not presented on this table: one

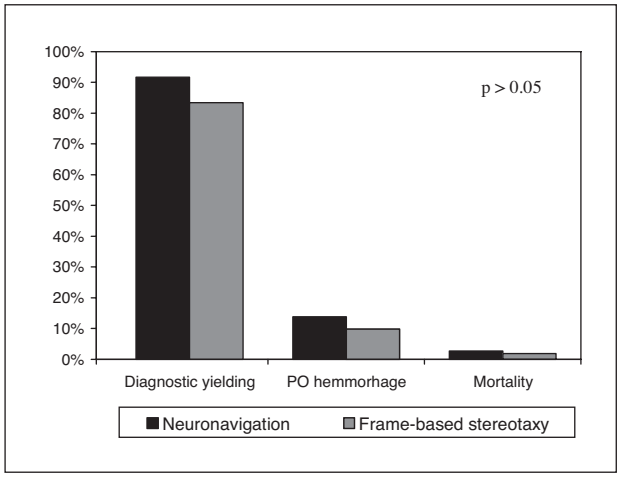

Fig 2. Graphic showing diagnostic yielding, post-operative hemorrhage, and mortality rates on both methods studied.

was treated with corticoid without defined diagnosis, a second non-diagnosed case was diagnosed by frameless biopsy, the third one needed craniotomy for tumoral resection, and the latter died before a second biopsy.

DISCUSSION

According to a meta-analysis of 7471 frameless biopsies the method achieves a diagnostic yielding of 91%, morbidity of 3,5%, and mortality of 0,7%[25]. Other studies show that frameless cerebral biopsy can be as precise as, or even more, than frame-based stereotaxy[21,25,26]. Mean localization error is similar in both methods[25,27].

Difficulties on frameless biopsies are many. Its targeting precision is intimately related to pre-operative radiological imaging that needs a well defined protocol[26]. Its adequate using depends on imaging manipulation and proper array of equipment on operation room. For fewer targeting errors it is necessary an adequate registration of cranial surface points. Depending on the method used for this registration, neuronavigation accuracy can be lowered down[28]. Neuronavigation biopsies of about 1 cm lesions, profound lesions, and posterior fossa lesions are usually less accurate than frame-based biopsies[22]. Brain shift after trepanation and dural opening is not so important compared to open craniotomy[29]. We use frame-base biopsy for lesions as small as 1 cm. Neuronavigation is usually done with general anesthesia while frame-based biopsy are normally performed with patient sedation and local anesthesia which permits a better neurological evaluation just after the procedure[29]. Costs for neuronavigation acquisition are high considering a emerging country like Brazil, but long term neuronavigation cost evaluation seems to be lower[29].

Our study shows similar results on both methods compared to the literature considering diagnostic yielding, pos-operative hemorrhage, and mortality rates[24]. Post-operative hemorrhage rates of 13.8% for the neuronavigation group, and 9,8% for the frame-based group are expected on the post-operative CT scans. These rates are justified because all patients studied are from an oncology center with predomination of astrocitic lesions. It is well known that glioma biopsies tends to have higher post-operative hemorrhage rates, specially those located at eloquent areas and deep seated[17]. Mortality related to volumous post-operative hemorrhage found on our study are compared to those found in the literature, i.e., 2.7% for neuronavigation group, and 1.9% for frame-based biopsies[6,30]. That is why patients with hemorrhage at biopsy site on CT-scan must stay on hospital for observation and new imaging[6]. Post-operative hemorrhages found on our study were found on gliomas extending to the corpus callosum, or to the thamalus and mesencephalon. Exception was a patient with a huge fronto-tempo-ro-insular lesion with negative frame-based biopsy that died without diagnosis.

Neuronavigation-guided cerebral biopsy is a very useful method for the neurosurgeon armamentarium. Advantages over frame-based stereotaxy are many, and similar diagnostic yielding, post-operative hemorrhage, and mortality rates are found. Using neuronavigation for cerebral biopsies of lesions bigger than 1 cm have many justifiable advantages: great acceptance by the patient avoiding frame fixation; there is no need to transport the patient immediately to and from the CT scan suite, mainly in children, for example, under general anesthesia; pre-operative MRI for frameless biopsy can be performed some days before surgery in contrast to frame-based biopsy that needs CT-scan just before it; a better security perception by the neurosurgeon who have instruments, target, and trajectory real-time images; possibility for changing target and trajectory during surgery without new stereotactic calculations; better system ergonomics with needle holder, infrared antenna, and star-shape head position tool all articulated in contrast to the volumous stereotactic frame.

Even thought frame-based biopsy still holds an important position on treating intracranial mass lesions because its cost accessibility, and its high diagnostic rates specially considering tumors of 1 cm or less, new software and equipment development tend to make neuronavigation an even more diffused method among neurosurgeons with lesser acquisition costs and better precision.

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