ORIGINAL PAPER/*ARTYKUŁ ORYGINALNY*

Intraoperative magnetic resonance-guided frameless stereotactic biopsies – initial clinical experience

Stereotaktyczne biopsje guzów wewnątrzczaszkowych z zastosowaniem rezonansu śródoperacyjnego

Marcin Czyż[1], Paweł Tabakow[1], Włodzimierz Jarmundowicz[1], Bogusława Lechowicz-Głogowska[2]

[1]Katedra i Klinika Neurochirurgii, Akademia Medyczna we Wrocławiu
[2]Katedra i Klinika Anestezjologii i Intensywnej Terapii, Akademia Medyczna we Wrocławiu

Neurologia i Neurochirurgia Polska 2012; 46, 2: 157-160
DOI: 10.5114/ninp.2012.28258

Abstract

Background and purpose: We present our early experience in intraoperative magnetic resonance (iMRI)-guided stereotactic frameless biopsies with special regard to its safety, efficacy and diagnostic value.
Material and methods: The records of patients who underwent frameless stereotactic iMRI-guided biopsies between June 2009 and April 2011 were analysed prospectively. All the operations were performed under local anaesthesia, with the use of a passive side-cutting biopsy needle. The needle was introduced into the pathological lesion with the help of optic neuronavigation system guidance. The iMRI scans served as reference images. We analysed the patients' demographic and epidemiological data, the preparation and surgery times, diagnostic values of collected specimens, lengths of the hospital stay (LOS) and the complication rate.
Results: Fifteen iMRI-guided stereotactic biopsies were performed in the analysed period. The mean patient age was 52 ± 18 yrs, the median WHO score was 2 (range: 1-3), there were 9 (60%) males in the study group. The average preparation time was 53 ± 24 minutes and the operation time 69 ± 25 minutes. No major complications were noted. The median total length of hospital stay was 5 days. The histopathological diagnoses were as follows: glioblastoma mul-

Streszczenie

Wstęp i cel pracy: W pracy przedstawiono doświadczenia własne z zastosowania niskopolowego śródoperacyjnego rezonansu magnetycznego (iMRI) w biopsjach stereotaktycznych guzów mózgu. Celem pracy było przedstawienie techniki operacji oraz analiza bezpieczeństwa i skuteczności diagnostycznej procedury.
Materiał i metody: Analizie poddano dane pacjentów, u których w okresie od czerwca 2009 r. do kwietnia 2011 r. wykonano bezramowe stereotaktyczne biopsje patologii wewnątrzczaszkowych. Operacje wykonywano drogą otworu trepanacyjnego z wykorzystaniem pasywnej igły biopsyjnej z bocznym oknem tnącym. Igłę wprowadzano w obręb zmiany patologicznej według wskazań systemu neuronawigacji optycznej, opartych na skanach iMRI. Prospektywnej ocenie poddano dane demograficzne i epidemiologiczne, czas przygotowań i czas operacji, wartość diagnostyczną pobranego materiału, częstość powikłań oraz długość hospitalizacji.
Wyniki: W analizowanym okresie wykonano 15 biopsji stereotaktycznych z wykorzystaniem iMRI. Średni wiek pacjentów wynosił 52 ± 18 lat, mediana WHO – 2, mężczyźni stanowili 60% operowanych. Średni czas przygotowań do operacji wynosił 53 ± 24 min, średni czas operacji 69 ± 25 min. W ocenianej grupie pacjentów nie stwierdzono powikłań neu-

Correspondence address: dr Marcin Czyż, Department of Neurosurgery, Wroclaw Medical University, ul. Borowska 213, 50-556 Wrocław, Poland, phone/fax: +48 71 734 34 00, e-mail: mt.czyz@gmail.com
Received: 8.08.2011; accepted: 9.01.2012

tiforme – 6 cases, low-grade gliomas – 4 cases, lymphomas – 3 cases, and other pathologies – 2 cases. In all the cases biopsy material allowed specified histopathological diagnoses to be obtained.

Conclusions: Frameless stereotactic iMRI-guided brain tumour biopsy is a safe and diagnostically effective procedure. The use of iMRI might increase the diagnostic value and safety of stereotactic biopsy and positively influence its economic balance.

Key words: intraoperative magnetic resonance, stereotactic biopsy, neurooncology.

rologicznych, krwotocznych i infekcyjnych. Średni czas hospitalizacji wynosił 5 dób. W badaniach histopatologicznych stwierdzono: 6 glejaków nisko zróżnicowanych, 4 glejaki wysoko zróżnicowane, 3 chłoniaki oraz 2 inne patologie.

Wnioski: Stereotaktyczne biopsje guzów mózgu z wykorzystaniem iMRI mogą być tak samo bezpieczne jak wykonywane w sposób klasyczny. Zastosowanie iMRI może zwiększyć ich skuteczność diagnostyczną oraz wpływać pozytywnie na bilans ekonomiczny procedury.

Słowa kluczowe: śródoperacyjny rezonans magnetyczny, biopsja stereotaktyczna, neuroonkologia.

Introduction

Stereotactic brain biopsy is a relatively straightforward, accurate, and safe method of obtaining diagnostic tissue [1] in cases of brain tumours which are doubtful in neuroimaging appearance or eloquently localized. Frameless computer-based neuronavigation is now widely used in brain tumour surgery. It has many advantages over frame-based techniques, and provides similar accuracy to the rigid frame [2]. Although its median diagnostic yield reaches a relatively high value of 95%, there is still an obvious need to search for techniques to improve this rate. One of the methods proposed is the use of intraoperative magnetic resonance imaging (iMRI), proposed by Bernays *et al.* in 2002 [3]. It offers intraoperative control of the proper targeting and tissue sampling and immediate diagnosis of even mild postoperative bleeding. The usefulness of ultra-low-field iMRI in stereotactic brain biopsy was subsequently confirmed by Schulder *et al.* [4]. Although both authors named iMRI as a routine tool, they used dedicated, MRI compatible biopsy cannulas.

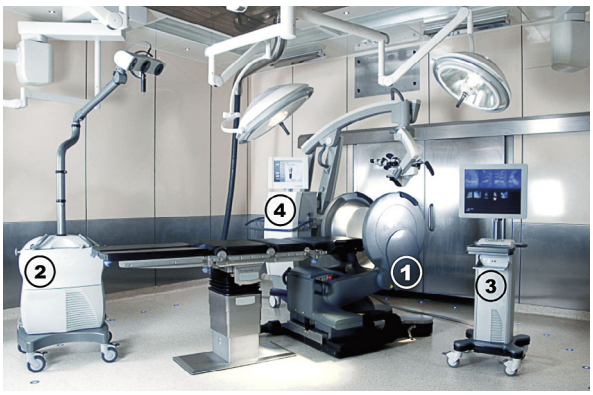

Fig. 1. Layout of neurosurgical operating room with 1) iMRI PoleStar N20, 2) neuronavigation camera, 3) neuronavigation station, 4) operating microscope

Based on our experience, we think that iMRI-guided stereotactic procedures can be safely and effectively performed with the standard passively navigated side-cutting biopsy needles. Our prospective study was conducted to provide further information based on a pilot group of consecutive patients who underwent frameless stereotactic biopsy procedures aided by iMRI imaging.

Material and methods

All patients who underwent a stereotactic frameless iMRI-guided biopsy between June 2009 and April 2011 were enrolled sequentially in the study. During the procedure, the head of each patient was immobilized with a 3-pin iMRI-compatible headholder. The PoleStar N20 iMRI system (Medtronic Navigation, Louisville, CO, USA) with a 0.15-T constant magnet was used in all procedures. The operating room was set up in a similar fashion as in tumour removal procedures, described previously [5,6]. The equipment of the neurosurgical operating room in typical configuration is shown in Fig. 1. Subsequently, after the patient's positioning, the preoperative reference examination was routinely carried out. Images were automatically transferred to the neuronavigation system (StealthStation, Medtronic Navigation, Louisville, CO, USA). The entry point, target and optimal biopsy trajectory were then defined by the operator on the basis of the obtained iMRI images. All frameless stereotactic biopsies were performed via a 6-mm burr hole using the Vertec system (Medtronic Navigation, Louisville, CO, USA). A side cut 2.2-mm diameter passive biopsy needle (Medtronic Navigation, Louisville, CO, USA) was used. One to twelve tissue samples were collected according to the procedure described by Shooman *et al.* [7]; the target number of tissue samples was 12, but after finding the presence of

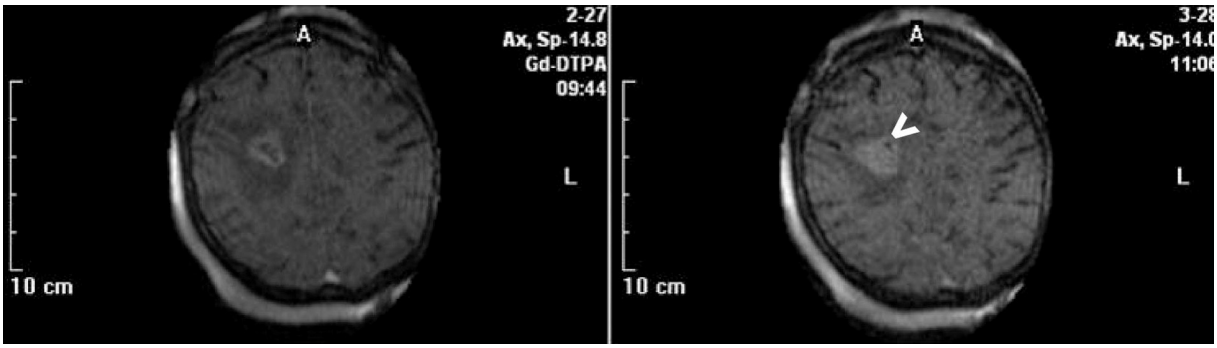

Fig. 2. Intraoperative MR images of the right frontal lobe contrast-enhancing tumour obtained with the use of iMRI PoleStar N20. Left image: preoperative iMRI axial scan, which served as a reference for the neuronavigation system. Right image: postoperative iMRI control scan on the same localization. Contrast extravasation could be a symptom of mild postoperative bleeding at the site of the biopsy. The biopsy site is visible as a black spot – small air bubble indicated by arrow

fresh blood in the biopsy needle the sampling was terminated. Following each operation, a control iMRI was routinely performed to confirm and document the proper targeting and exclude postoperative hyperacute intraparenchymal bleeding (Fig. 2). Furthermore, a postoperative follow-up head CT was also performed 4 to 6 hours after each procedure.

We prospectively collected and statistically analysed the following data: demographic and epidemiological information, the preparation and operation time, the location and size of the pathological lesion, postoperative complications (wound infection, neurological deterioration), the length of hospital stay (LOS) and the diagnostic yield.

Results

Fifteen iMRI-guided stereotactic biopsies were carried out in the analysed period. The mean patient age was 52 ± 18 years, the median WHO score was 2 (range: 1-3), there were 9 (60%) males in the study group. The mean preparation time was 53 ± 24 minutes and the operation time 69 ± 25 minutes. Temporary or permanent neurological deterioration as well as wound infections were not noted. The follow-up head computed tomography (CT) performed 4 to 6 hours after the operation did not reveal expansive intraparenchymal haematomas in any patient. The median total LOS was 5 days. The histopathological diagnoses were as follows: glioblastoma multiforme – 6 cases, low-grade gliomas – 4 cases, lymphomas – 3 cases, 1 case of metastasis and 1 case of spongiform encephalopathy. In all the listed cases, biopsy material allowed specified histopathological diagnoses to be obtained. All the variables are presented in Table 1.

Discussion

We present the first series of iMRI-guided biopsy procedures which did not use intraoperative visualization of the MRI-compatible biopsy needle [3,4,8]. Instead, we used a standard side cutting passively navigated device. Moreover, we were able to verify intraoperatively the accuracy and safety of the procedure, using iMRI performed just after the biopsy needle withdrawal. In all the cases, there was an air-bubble corresponding to the site of tissue sampling. According to Bernays *et al.* [3], it was also possible to exclude intraoperatively the presence of intraparenchymal bleeding, which makes the need for a follow-up CT questionable. However, this thesis has not been proven yet and needs to be confirmed in an evidence-based manner.

In case of the iMRI-based stereotactic procedure, there is no need to register the patient's head. This can be considered as another technical and economic advantage of the procedure, as there was no need to perform preoperative high field 3D MRI or 3D head CT. In our series we were also able to intraoperatively react to a brain shift, which was present in one case. After the burr hole had been made there was a significant brain shift observed, which was probably caused by a massive leakage of the CSF. Due to the risk of inadequacy of the preoperatively designed biopsy trajectory, we decided to perform another iMRI reference scan and realigned the needle track. According to the analysis of the intraoperatively collected images there was no need to change the direction of the needle insertion; the depth was however increased by 4 mm. Diagnostic material from the deep seated lesion of the dominant brain hemisphere was subsequently obtained.

Table 1. Variables analysed among studied patients

Variables	Observations (*n* = 15)
Preoperative factors (group A)	
Age	52 ± 18
Sex [male]	60%
WHO score	2 (1-3)
Total Karnofsky score before the operation	90 (70-90)
Tumour diameter [mm]	48 ± 19
Contrast enhancement	80%
Factors associated with the operation (group B)	
Preparation time [min]*	53 ± 24
Operation time [min]**	69 ± 25
Complications	0%
Total Karnofsky score after the operation***	90 (70-90)
Hospitalization time [days]	5 (3-8)
Technical factors (group C)	
Number of positioning scans	1 (1-2)
Number of intraoperative scans	2 (1-3)
Intraoperative pathology visualisation	100%
Histopathological diagnosis	100%

Values are presented as %, as median (interquartile range) or mean ± standard deviation
WHO score – ECOG Performance Status [10]
**Period from the moment of conscious patient arriving at the operating room to the moment of skin incision*
***Period from the moment of skin incision to the last suture insertion*
****On the day of discharge*

While the efficacy of iMRI guidance in brain abscess aspiration is unquestionable [9], there is still no evidence proving the necessity of using intraoperative imaging in carrying out stereotactic biopsies. However, a high diagnostic yield and no complications observed in our group allow us to consider iMRI-guided stereotactic biopsy as a good alternative for a widely known frameless stereotactic biopsy based on the obtained preoperative high resolution images. To compare the effectiveness and safety of both types of operations, a prospective study involving a larger group of patients should be designed and performed.

Conclusions

1. Frameless stereotactic iMRI-guided brain tumour biopsy is a safe and diagnostically effective procedure.
2. The use of iMRI may increase the diagnostic value of stereotactic biopsy by eliminating the negative influence of brain shift.
3. Further controlled studies in larger prospective groups of patients are needed to demonstrate the possible drawbacks and determine the economic balance of both types of operations.

Acknowledgements

This study was presented during the 40th Congress of the Polish Society of Neurosurgeons, Wrocław, 15-18 September, 2011.

Disclosure

Authors report no conflict of interest.

References

1. Sawin P.D., Hitchon P.W., Follett K.A., et al. Computed imaging-assisted stereotactic brain biopsy: a risk analysis of 225 consecutive cases. *Surg Neurol* 1998; 49: 640-649.
2. Jain D., Sharma M.C., Sarkar C., et al. Comparative analysis of diagnostic accuracy of different brain biopsy procedures. *Neurol India* 2006; 54: 394-398.
3. Bernays R.L., Kollias S.S., Khan N., et al. Histological yield, complications, and technological considerations in 114 consecutive frameless stereotactic biopsy procedures aided by open intraoperative magnetic resonance imaging. *J Neurosurg* 2002; 97: 354-362.
4. Schulder M., Spiro D. Intraoperative MRI for stereotactic biopsy. *Acta Neurochir Suppl* 2011; 109: 81-87.
5. Senft C., Franz K., Ulrich C.T., et al. Low field intraoperative MRI-guided surgery of gliomas: a single center experience. *Clin Neurol Neurosurg* 2010; 112: 237-243.
6. Czyz M., Tabakow P., Lechowicz-Głogowska B., et al. Prospective study on the efficacy of the low field intraoperative magnetic resonance imaging (iMRI) application in neurosurgical operations. *Neurol Neurochir Pol* 2011; 45: 226-234.
7. Shooman D., Belli A., Grundy P.L. Image-guided frameless stereotactic biopsy without intraoperative neuropathological examination. *J Neurosurg* 2010; 113: 170-178.
8. Quinn J., Spiro D., Schulder M. Stereotactic brain biopsy with a low-field intraoperative magnetic resonance imager. *Neurosurgery* 2011; 68: 217-224; discussion 224.
9. Gasser T., Senft C., Rathert J., et al. The combination of semi-sitting position and intraoperative MRI – first report on feasibility. *Acta Neurochir* (*Wien*) 2010; 152: 947-951.
10. Oken M.M., Creech R.H., Tormey D.C., et al. Toxicity and response criteria of the Eastern Cooperative Oncology Group. *Am J Clin Oncol* 1982; 5: 649-655.