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Technical note

Diffuse intrinsic pontine gliomas in children: Interest of robotic frameless assisted biopsy. A technical note

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ABSTRACT

Introduction. – Diffuse intrinsic pontine gliomas (DIPG) constitute 10–15% of all brain tumors in the pediatric population; currently prognosis remains poor, with an overall survival of 7–14 months. Recently the indication of DIPG biopsy has been enlarged due to the development of molecular biology and various ongoing clinical and therapeutic trials. Classically a biopsy is performed using a stereotactic frame assisted procedure but the workflow may sometimes be heavy and more complex especially in children. In this study the authors present their experience with frameless robotic-guided biopsy of DIPG in a pediatric population.

Patients and methods. – Retrospective study on a series of five consecutive pediatric patients harboring DIPG treated over a 4-year period. All patients underwent frameless robotic-guided biopsy via a transcerebellar approach.

Results. – Among the 5 patients studied 3 were male and 2 female with a median age of 8.6 years [range 5 to 13 years]. Clinical presentation included ataxia, hemiparesis and cranial nerve palsy in all patients. MRI imaging of the lesion showed typical DIPG features (3 of them located in the pons) with hypo-intensity on T1 and hyper-intensity signal on T2 sequences and diffuse gadolinium enhancement. The mean procedure time was 56 minutes (range 45 to 67 minutes). No new postoperative neurological deficits were recorded. Histological diagnosis was achieved in all cases as follows: two anaplastic astrocytomas (grade III), two glioblastomas, and one diffuse astrocytoma (grade III).

Conclusion. – Frameless robotic assisted biopsy of DIPG in pediatric population is an easier, effective, safe and highly accurate method to achieve diagnosis.

1. Introduction

Diffuse intrinsic pontine gliomas (DIPG) constitute 10–15% of all brain tumours in the paediatric population [1]. Children in mid to late childhood are mostly affected, with a mean age of 9.6 years [2,3]. Currently prognosis in children with malignant brainstem glioma remains poor; the overall survival is estimated between 7 and 14 months with a median survival of 9 to 12 months [2,4,5].

Currently, the diagnosis of DIPG based only on imaging and clinical features is considered a suboptimal standard of care [6]. The diagnosis of DIPG is now performed with the new histological insights based on the molecular status of histone H3.3 which requires a routine biopsy to obtain tumor samples.

Biopsy data on pediatric DIPG yielded a diagnosis from 96 to 100%, with no mortality and procedure related morbidity was less than 5% [7]. Despite some morbidity, a biopsy allows molecular biology analysis and in the present and near future the development of clinical trials of targeted therapies [7–11].

Despite the narrow posterior fossa in children, frame-based stereotactic biopsy is reliable, accurate and safe for the diagnosis of DIPG [7,12]. Nevertheless, the frame-based procedure may sometimes complicate surgical workflow. Frameless systems and especially robotic-guided procedure may actually simplify management.

To date only few papers have reported this type of a robotic assisted procedure of a brainstem lesion [13].

The aim of our study was to report our experience regarding frameless robotic stereotactic assisted biopsy by transcerebellar approach in DIPG, focusing on its feasibility, safety and accuracy.

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Table 1
Summary of demographic, clinical and radiological features of five cases of DIPG.

Case	Sex	Age (y)	Clinical presentation	Imaging location	Approach	Complications during procedure	Complications after procedure	Pathology	Mutations	Overall survival (months) until death
1	F	11	Ataxia	Diffuse pontine lesion, mesencephalic extension	Transcerebellar	None	None	Glioblastoma	Histone H3.3 K27M ATRX loss	8
2	M	7	Hemiparesis, oculomotor palsy	Diffuse pontine lesion, middle cerebellar peduncle extension	Transcerebellar	None	None	Anaplastic Grade III Astrocytoma	Histone H3.3 K27M ATRX loss	7
3	M	7	Facial palsy	Diffuse pontine lesion	Transcerebellar	None	None	Glioblastoma	No histone mutation ATRX loss	9
4	F	5	Hemiparesis	Diffuse pontine lesion	Transcerebellar	None	None	Anaplastic Grade III Astrcytoma	Histone H3.1 K27M	11
5	M	13	Ataxia, oculomotor palsy	Diffuse pontine lesion	Transcerebellar	Transitory bradycardia	None	Diffuse Grade III Astrocytoma	Histone H3.3 K27M and PI3KCA mutations ATRX loss	9

M: male; F: female; y: years.

2. Patients and methods

Retrospective study based on a series of five consecutive patients with DIPG treated at our institution during 4 years (from January 2012 to December 2015). MRI Imaging was consistent with DIPG (with > 50% of brainstem infiltration); all patients underwent brainstem biopsy via a frameless robotic stereotactic device (ROSA, Medtech®). Presenting symptoms, imaging and outcome are summarized in Table 1.

The reference imaging used to plan the procedure was the T1 3D Gadolinium enhanced sequences (1 m slice thickness, 320 × 260 pixels) performed 48–72 hours prior to the procedure.

The biopsy needle targeting and trajectory were planned the day before surgery on a computer workstation using robot-planning software (Rosana, Medtech®).

The target zone was chosen within the most enhanced area in the MRI and trajectory passing through the middle cerebellar peduncle. The side entry point was determined using the tumor lateral predominance (Fig. 1).

The stereotactic biopsy procedures were performed under general anesthesia. The patient was placed in a supine position with a mild elevation and tilting of the ipsilateral shoulder to allow easier access to the entry point. The head was fixed and secured in a three-pin headrest attached to the robotic device; special attention was paid to ensure the previously planned trajectory.

Automatic robotic frameless surface facial merge registration (without fiducial markers) was performed and accuracy of the registration was confirmed by the surgeon (Fig. 2). Sterile draping was performed and the previously planned trajectory was reached by the robotic arm (ROSA Medtech®), which also served as an instrument holder.

A 0.5-cm skin incision was performed without previous shaving. All instruments were positioned and used through an adapted holder by the robotic arm.

The bone opening was performed using a 3.2-mm twist drill. Dura mater was opened using a blunt stylet. The tumor sampling was performed with a 2.5 mm side cutting biopsy needle. At least 4 samples were obtained (by a quarter technique) in all cases (Fig. 3).

Needle progression was closely controlled during the procedure, and before needle removal we injected 0.5 ml of air in the target to confirm precision of the sampling on a postoperative CT scan (Fig. 4). An absorbable suture was used for skin closure.

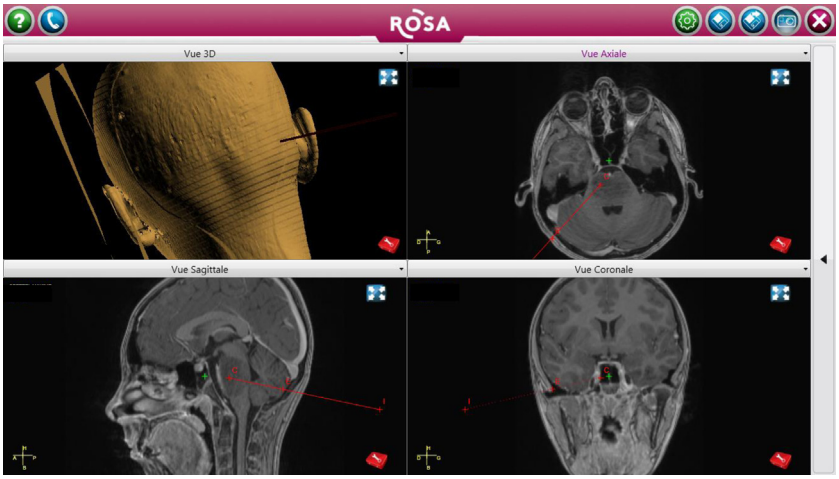

Fig. 1. Sagittal 3D T1 weighted enhanced MRI sequences showing a hypointense pontine lesion with little enhancement in patient suffering of oculomotor palsy and ataxia. Target determination with Rosana Medtech® software, the right side of the tumor is targeted as contrast enhancement is more evident. The transcerebellar route is explored and verified. Reconstruction of 3D MRI and simulation is made to ensure the absence of conflict between the entry point and the cranial fixation during surgery.