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Image Guidance for Placement of Ommaya Reservoirs: Comparison of Fluoroscopy and Frameless Stereotactic Navigation in 145 Patients

Peter F. Morgenstern[1,3], Scott Connors[3], Anne S. Reiner[4], Jeffrey P. Greenfield[1-3]

■ OBJECTIVE: **Ommaya reservoirs are used for administration of intrathecal chemotherapy and cerebrospinal fluid sampling. Ventricular catheter placement for these purposes requires a high degree of accuracy. Various options exist to optimize catheter placement. We analyze a cohort of patients receiving catheters using 2 different technologies.**

■ METHODS: **Retrospective chart review was performed on patients undergoing Ommaya reservoir placement between 2011 and 2014. Most procedures were assisted by either frameless stereotactic neuronavigation or fluoroscopic guidance with pneumoencephalogram. Catheter accuracy, revision rates, perioperative complications, and operative time were measured. Preoperative similarities and differences in diagnosis, demographics, and ventricular size were also recorded to avoid a biased assessment of our results.**

■ RESULTS: **One-hundred and forty-five patients were included, 57 using fluoroscopic guidance and 88 using frameless stereotaxy. Common diagnoses in both groups were lymphoma and leptomeningeal disease. Qualitative measures of catheter placement accuracy showed no significant difference between the 2 groups. Proximity to the foramen of Monro favored fluoroscopy by a small margin (8.6 mm vs. 10.2 mm, $P = 0.03$). Overall revision rates were not significantly different between the groups (3.5% vs. 4.5%, $P = 1.00$). Early surgical complications occurred in 6.8% of the frameless stereotaxy group and 1.8% of the fluoroscopy group ($P = 0.25$).**

■ CONCLUSIONS: **Ommaya reservoirs can be placed accurately using different methods. Although there are slight differences between fluoroscopy and frameless stereotaxy in quantitative accuracy and procedure time, there is no significant advantage of 1 method over the other when evaluating revision or complication rates. Technique familiarity and surgeon preference may dictate the preferred procedure.**

INTRODUCTION

First described in the 1960s,[1] Ommaya reservoir placements have various applications, most notably allowing ventricular access for sampling and therapy in cancer. For pediatric and adult leptomeningeal disease, leukemia, lymphoma, and other cancers, this device has allowed clinicians to limit the use of repeated lumbar punctures for diagnostic and therapeutic purposes.[2-4]

Ventricular catheter placement associated with an Ommaya reservoir has been accomplished by several techniques over the years. A freehand catheter technique was used initially, but over the years it has been largely supplanted by various forms of image guidance as technology has improved and practitioners have recognized that freehand placement is associated with a high rate of failure.[5-10] Image guidance has been accomplished over the years by many modalities, including ultrasound, pneumoencephalogram with fluoroscopy, frame-based stereotaxy, and frameless stereotaxy. Each of these techniques has technical advantages and drawbacks, but comparison of the accuracy and safety of these techniques in the literature is sparse.[6,11] Recent work has detailed the value of using frameless stereotactic guidance for ventriculoperitoneal shunt placement, as well as comparison of frame-based and frameless stereotaxy for Ommaya

Key words
- Fluoroscopy
- Frameless stereotaxy
- Neuronavigation
- Ommaya reservoir
- Ventricular catheter

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
CT: Computed tomography
FOR: Frontal-occipital horn ratio

From the Departments of [1]Neurological Surgery, New York Presbyterian Hospital—Weill Cornell Medical Center, [3]Neurosurgery, and [4]Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center; and [2]Weill Cornell Medical College, New York, New York, USA

To whom correspondence should be addressed: Peter F. Morgenstern, M.D.
[E-mail: pfm2001@nyp.org]

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placement. These studies have demonstrated the safety and accuracy of ventricular catheter placement by frameless stereotaxy.[11-13] In addition to use of frameless stereotaxy, we continue to use fluoroscopic guidance with air ventriculography to facilitate placement of Ommaya reservoirs. In this study we compare a large cohort of patients undergoing Ommaya reservoir placement using these 2 common guidance modalities, assessing their safety and accuracy.

METHODS

Study Criteria

This study was approved by the institutional review boards of New York Presbyterian Hospital—Weill Cornell Medical Center (NYP-WC) and Memorial Sloan Kettering Cancer Center (MSKCC). Patients were identified by query of medical records at both institutions using billing codes associated with Ommaya reservoir and catheter placement (61210 and 61215) between 2011 and 2014. All identified patients were then screened by chart review for accurate classification of the procedure before proceeding with additional data collection. All patients undergoing Ommaya reservoir and ventricular catheter placement for cerebrospinal fluid (CSF) sampling and/or intrathecal chemotherapy administration using either fluoroscopic or frameless stereotactic guidance (Brainlab AG, Munich, Bavaria) were included. Our initial query included patients in whom a "freehand" or endoscopic-assisted placement were performed as well, but patient numbers in these groups were so small—3 and 7, respectively—that they could not be included in the statistical analysis.

Data Collection and Outcome Variables

Basic demographic and diagnosis information was collected by review of patient records. Operative notes were reviewed to determine the type of image guidance (if present) used for placement of the ventricular catheter. Preoperative and postoperative computed tomography (CT) and magnetic resonance imaging (MRI) scans were reviewed in a blinded fashion to determine preoperative ventricular size using frontal and occipital horn ratio (FOR) and accuracy of catheter placement qualitatively and quantitatively. Catheters were assessed for qualitative accuracy using a grading scale described by Hayhurst et al.[14] This 3-grade scale is as follows: 1) catheter tip floating in CSF, away from choroid and a straight trajectory from the burr hole; 2) catheter tip touching ventricle wall or choroid; or 3) part of catheter tip within parenchyma or failure to cannulate the targeted ventricle.[14] Quantitative assessment of catheter accuracy was determined by measurement of the distance from the Foramen of Monro in the anteroposterior (AP), lateral (right-left), and craniocaudal dimensions and combining these measurements by the following calculation: $\text{Distance} = \sqrt{AP^2 + RL^2 + CC^2}$. Procedure time, perioperative complications, follow-up time, and revisions were also recorded. The number of transcortical catheter passes was considered in assessing safety and ease of the selected modalities but was documented too infrequently to assess.

Statistical Methods

Descriptive statistics such as frequencies, medians, and means were used for characterizing the population under study. Associations between categorical variables of interest and guidance method groups (Frameless Stereotaxy and Fluoroscopy) were analyzed with the chi-square test or Fisher's exact test. Associations between continuous variables of interest and guidance method groups were analyzed with the Wilcoxon rank sum test. All *P* values were 2-sided with a level of significance less than 0.05, and all statistical analyses were done in SAS (version 9.4, Cary, North Carolina, USA).

RESULTS

Seventy-four men and 71 women underwent Ommaya reservoir placement with a ventricular catheter between 2011 and 2014. Of these, 57 catheters were placed using fluoroscopic guidance and 88 were placed using frameless stereotaxy. The most common diagnosis in both groups was lymphoma, which included primary and metastatic disease and comprised 54% of the overall cohort. The second most common diagnosis was leptomeningeal metastatic disease originating from a solid tumor, which represented 21% of the total cohort. The distribution of diagnoses was different between the 2 groups (Table 1). There were no deaths during the follow-up period.

Procedure time data were available in the medical record for 122 of the 145 patients in the study, with data unavailable for 21

Table 1. Demographic Data for 145 Patients with Ommaya Reservoir Placement

	Total (n = 145)	Fluoroscopy (n = 57)	Frameless Stereotaxy (n = 88)	*P* value*
Age (years)				0.28
Mean	50.8	56.3	47.3	
Median, IQR	56.7, 42.2–66.4	56.6, 47.9–67.0	57.5, 25.0–65.9	
Sex, number (%)				1
Male	74 (51)	29 (51)	46 (52)	
Female	71 (49)	28 (49)	42 (48)	
Diagnosis, number (%)				0.03
Lymphoma	79 (54)	34 (60)	45 (51)	
Leptomeningeal disease	30 (21)	16 (28)	14 (16)	
Leukemia	13 (9)	3 (5)	10 (11)	
Other†	23 (16)	4 (7)	19 (22)	
Follow-up (days)				0.65
Mean	408.6	448.3	382.9	
Median, IQR	167, 47–571	163, 54–593	169, 39–569	

IQR, interquartile range.
**P* values are calculated for the variable of interest by fluoroscopy or frameless stereotaxy. The Wilcoxon rank sum test was used for continuous variables, and the Fisher's exact test or chi-square test was used for categorical variables.
†Glioblastoma, medulloblastoma, multiple myeloma, neuroblastoma, retinoblastoma.