Endoscopic approach to colloid cyst: what is the optimal entry point and trajectory?

Clinical article

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**Object.** An optimal entry point and trajectory for endoscopic colloid cyst (ECC) resection helps to protect important neurovascular structures. There is a large discrepancy in the entry point and trajectory in the neuroendoscopic literature.

**Methods.** Trajectory views from MRI or CT scans used for cranial image guidance in 39 patients who had undergone ECC resection between July 2004 and July 2010 were retrospectively evaluated. A target point of the colloid cyst was extended out to the scalp through a trajectory carefully observed in a 3D model to ensure that important anatomical structures were not violated. The relation of the entry point to the midline and coronal sutures was established. Entry point and trajectory were correlated with the ventricular size.

**Results.** The optimal entry point was situated 42.3 ± 11.7 mm away from the sagittal suture, ranging from 19.1 to 66.9 mm (median 41.4 mm) and 46.9 ± 5.7 mm anterior to the coronal suture, ranging from 36.4 to 60.5 mm (median 45.9 mm). The distance from the entry point to the target on the colloid cyst varied from 56.5 to 78.0 mm, with a mean value of 67.9 ± 4.8 mm (median 68.5 mm). Approximately 90% of the optimal entry points are located 40–60 mm in front of the coronal suture, whereas their perpendicular distance from the midline ranges from 19.1 to 66.9 mm. The location of the “ideal” entry points changes laterally from the midline as the ventricles change in size.

**Conclusions.** The results suggest that the optimal entry for ECC excision be located at 42.3 ± 11.7 mm perpendicular to the midline, and 46.9 ± 5.7 mm anterior to the coronal suture, but also that this point differs with the size of the ventricles. Intraoperative stereotactic navigation should be considered for all ECC procedures whenever it is available. The entry point should be estimated from the patient’s own preoperative imaging studies if intraoperative neuronavigation is not available. An estimated entry point of 4 cm perpendicular to the midline and 4.5 cm anterior to the coronal suture is an acceptable alternative that can be used in patients with ventriculomegaly.

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**Key Words** • hydrocephalus • colloid cyst • entry point • trajectory • image guidance • endoscopy • neuroendoscopy • surgical technique

Colloid cysts are benign lesions that account for 0.5%–2% of all intracranial tumors. They are typically located at the roof of the third ventricle near the foramen of Monro. They present with signs and symptoms of hydrocephalus by interfering with the normal CSF flow. There are different surgical treatments, including microsurgical resection, endoscopic resection, stereotactic aspiration, and ventriculoperitoneal shunt implantation. Nowadays, the most popular approaches are microsurgical and endoscopic resection. Transcortical or transcallosal are the two microsurgical approaches for colloid cyst resection.

Increasingly, less invasive endoscopic approaches are used to address these lesions in an effort to minimize perioperative morbidity. With recently improved neuroendoscopic techniques, the number of cases with endoscopic excision is rising. As part of the endoscopic procedure, selection of an entry point is crucial. The location of the entry point determines the trajectory the endoscope follows. Identifying a good entry point and trajectory not only facilitates the procedure, but more importantly, it helps to avoid jeopardizing the key anatomical structures such as the caudate nucleus, deep cerebral veins, and the fornicei. Intraoperative trauma to the fornix could result from pressing this structure or swinging the scope laterally or anteroposteriorly, either during the access to or removal of the lesion. The effect of such damage on memory can range from imperceptible to disabling. These complications can be reduced by using an optimal entry point that traverses the foramen of Monro without the need to swing the endoscope back and forth or from side to side.

One of the arguments against an endoscopic approach relative to the conventional transcortical or transcallosal approach is the greater probability of incomplete lesion removal with endoscopy. Gross-total resection can also probably be achieved by carefully choosing an optimal trajectory. However, the selection of the trajectory to the colloid cyst differs a great deal in the literature. The

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**Abbreviations used in this paper:** ECC = endoscopic colloid cyst; FH = frontal horns; ID = internal distance.

This article contains some figures that are displayed in color online but in black-and-white in the print edition.
Optimal entry point for endoscopic colloid cyst resection

The present study was performed to identify the optimal entry site and accordingly the ideal trajectory for the approach to the colloid cyst on volumetric images obtained preoperatively in patients who were about to undergo endoscopic procedures. The stereotactic plans were not the actual surgical trajectories. Scans of patients were analyzed to use their anatomy to project trajectories. We evaluated an “ideal” point based on anatomical landmarks in actual patients with colloid cysts to improve our practice and define an optimal entry point and trajectory.

Methods

We retrospectively reviewed charts of patients in whom endoscopic colloid cyst (ECC) resection was performed by the senior author. Demographic and clinical data were collected for each patient. Radiographic variables evaluated were as follows: presence of ventriculomegaly, colloid cyst size, presence of residual lesion on immediate and follow-up scans, and cyst recurrence at follow-up. All endoscopic procedures were performed using the dual-instrument endoscopic technique previously described by our group (Video 1).

Video 1. Clip showing procedure performed using image-guidance neuronavigation and an anterolateral approach, in which the ideal entry point and trajectory were selected. Important neurovascular structures such as caudate nucleus, thalamus, fornix, and thalamostriate and septal veins were avoided. A 30°-angle rigid endoscope and a dual-instrument technique were used. Complete colloid cyst resection was achieved with no complications. Copyright Leonardo Rangel-Castilla. Published with permission. Click here to view with Media Player. Click here to view with Quicktime.

This study was approved by the institutional review board of St. Joseph’s Hospital and Medical Center in Phoenix, Arizona. All patients were treated at Barrow Neurological Institute.

Patient Population

The images of 39 patients (21 males and 18 females) who underwent an ECC procedure with preoperative volumetric Stealth brain MRI study between July 2004 and July 2010 were analyzed retrospectively. The mean size of the colloid cyst was 12 ± 5 mm, ranging from the smallest (6.5 mm) to the largest (26.2 mm). Not all patients had ventriculomegaly.

Data Acquisition

The volumetric MRI studies were reloaded to a Medtronic Treon Stealth workstation (Medtronic, Inc.). The thin-cut scans with axial, coronal, and sagittal views were displayed on the workstation (Fig. 1). A target point on the colloid cyst was selected at a site where both the inferior and superior parts of the cyst were within easy reach (Fig. 1A). The other point was chosen as a preliminary entry point in either the right or the left frontal lateral ventricle (Fig. 1B). The two points were connected with a straight line. The connecting line was extended beyond the preliminary entry point until it intersected with the scalp. The meeting point of the extended line with the scalp was designated as a new preliminary entry point. The line connecting the new entry point with the target point was set as the preliminary trajectory.

A simulated wand was activated and the tip of this wand was advanced along the preliminary trajectory between the new preliminary entry and target points. The tip of the simulated wand ran between the preliminary entry point and the target point, and was carefully observed in a 3D fashion to ensure that the important surrounding anatomical structures such as the caudate nucleus and the fornix were not violated. The trajectory was adjusted by relocating the entry point until none of the aforementioned structures were gone through or in contact with the trajectory line. Once the trajectory was finalized it was set as an “ideal trajectory,” and the intersecting point of the “ideal trajectory” with the scalp was accordingly considered as an “ideal entry point” (Fig. 1C).

The perpendicular distance from the optimal entry point to the sagittal suture or midline and to the coronal suture was calculated. The distance from the optimal entry point to the target point was also obtained (Fig. 2). The sagittal plane was identifiable on axial images and the coronal suture was reproducibly identifiable by the break in signal from the bone marrow (Fig. 1D). To find if there was a correlation between the ventricle size and the optimal entry point, the ratio of the largest width between the frontal horns (FH) to the internal distance (ID) between internal tables on axial slices was also obtained in each patient.

Data Analysis

The distance from the optimal entry point to the sagittal suture, the coronal suture, and the target point was represented as the mean ± SD. The ratio of FH/ID was also reported as the mean ± SD. Statistical software (IBM SPSS, version 19) was used for descriptive and inferential data analysis. The correlation between the location of the optimal entry point, the ratio of FH/ID, and the distance from the entry point to the target was analyzed with bivariate correlate analysis. The correlation coefficient (r) ranges from −1 to +1. The confidence interval was set at 95% (α = 0.05).

Results

The optimal entry point was situated at 42.3 ± 11.7 mm away from the sagittal suture, ranging from 19.1 to 66.9 mm (median 41.4 mm) and 46.9 ± 5.7 mm anterior to the coronal suture, ranging from 36.4 to 60.5 mm (median 45.9 mm). The distance from the entry point to the target on the colloid cyst varied from 56.5 to 78.0 mm, with a mean value of 67.9 ± 4.8 mm (median 68.5 mm) (Fig. 2).

When the strength of the correlation between the distance of the entry point to the sagittal suture and the ratio of FH/ID was measured, r = 0.616 (p < 0.001) (Fig. 3 up-
per); the correlation analysis between the distance from the entry point to the coronal suture and FH/ID ratio revealed a correlation coefficient of 0.036 (p = 0.827) (Fig. 3 lower); and the measurement of the correlation between the entry-target distance and FH/ID ratio showed the correlation coefficient at 0.34 (p = 0.03).

Discussion

Surgical approaches to colloid cysts include transcallosal-transventricular, transcortical-transventricular, stereotactic cyst aspiration, and endoscopic excision with and without Stealth image guidance. Although each treatment modality has shown fairly good clinical outcome, there has been discussion about which approach is the procedure of choice, especially between transcallosal or transcortical and endoscopic excision. In comparison with the traditional transcallosal-transventricular or transcortical-transventricular approach and cyst aspiration with stereotactic guidance, the role of neuroendoscopy in removal of colloid cysts only started recently. It began with cyst aspiration aided by the endoscope. Powell et al. first reported endoscopic aspiration of colloid cysts in 1983. Although the debate over the clinical outcome between microsurgical and endoscopic resection followed almost immediately, colloid cyst cases treated with endoscopic removal are increasing relative to the conventional approach. In fact, if indicated, endoscope...
Optimal entry point for endoscopic colloid cyst resection

ic excision of the colloid cyst has become an approach of choice in major medical centers across the country. However, in the literature there is a large discrepancy between surgeons in selection of the entry point and trajectory.

Zohdi and El Kheshin took the Kocher point as the entry point. Lewis et al., King et al., Levine et al., Boogaarts et al. chose the entry point at 1 cm anterior to the coronal suture and 4–5 cm from the sagittal suture. Longatti et al., Rodziewicz et al., and Mishra et al. selected an entry point 1–4 cm anterior to the coronal suture and 2–5 cm relative to the midline. Teo recommended an entry point 11 cm posterior to the nasion and 5–6 cm away from the sagittal suture. Acerbi et al. used an entry point similar to Teo’s but 2 cm more medial. Delitala et al. used a more anterior point with a supraorbital approach at 1.5 cm above the orbital rim on the midpupillary line for better visualization of the cyst wall near the tela choroidea. Greenlee et al. introduced an entry point 8 cm away from the nasion posteriorly and 7 cm laterally from the midline in their relatively large case series. The choice of the entry points and subsequent trajectories is either arbitrary or based on experience in almost all reports (Table 1). There is no solid evidence in the literature supporting any of the current selection of the entry points or trajectories as the optimal one. This prominent discrepancy in determination of the entry point and trajectory clearly justifies the necessity for localization of an “ideal” entry point.

In the present study, the distance of the optimal en-

![Fig. 2. Scatterplot showing distribution of the entry points in 39 patients. Upper: Distribution of the entry points relative to the midline. Lower: Distribution of the entry points relative to the coronal suture.](image-url)
try from the midline varies much more than that from the coronal suture (Fig. 2). Approximately 90% of the optimal entry points are located 40–60 mm in front of the coronal suture, whereas its perpendicular distance from the midline ranges from 19.1 to 66.9 mm. The location of the “ideal” entry points changes laterally from the midline as the ventricles change in size. In other words, the larger the ventricle the more lateral the entry point can be. The correlation between the ratio of FH/ID and the distance of the entry point from midline is statistically significant (r = 0.616, p <

**Fig. 3.** Scatterplot showing correlation of the location of optimal entry points with the ratio of FH/ID (ratio of the largest width between the FH to the ID between internal tables). **Upper:** Correlation is significant at the 0.01 level (2-tailed). **Lower:** Correlation is not significant at either the 0.05 or 0.01 level (2-tailed). DTCS = distance to coronal suture; DTSS = distance to sagittal suture.
Optimal entry point for endoscopic colloid cyst resection

TABLE 1: Literature review of different parameters for selection of the entry point for ECC resection*

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Cases</th>
<th>Anteroposterior</th>
<th>Lateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lewis et al., 1994</td>
<td>7</td>
<td>1 cm ant to CS</td>
<td>5 cm</td>
</tr>
<tr>
<td>Abdou &amp; Cohen, 1998</td>
<td>13</td>
<td>ant to CS</td>
<td>midpupillary line</td>
</tr>
<tr>
<td>Decq et al., 1998</td>
<td>15</td>
<td>10 cm above sup orbital arch</td>
<td>3 cm</td>
</tr>
<tr>
<td>King et al., 1999</td>
<td>14</td>
<td>1 cm ant to CS</td>
<td>5 cm</td>
</tr>
<tr>
<td>Teo, 1999</td>
<td>18</td>
<td>11 cm pst to nasion</td>
<td>5–6 cm</td>
</tr>
<tr>
<td>Longati et al., 2000</td>
<td>61</td>
<td>1–4 cm ant to CS</td>
<td>2–5 cm</td>
</tr>
<tr>
<td>Rodziewicz et al., 2000</td>
<td>12</td>
<td>2 cm ant to CS</td>
<td>3–5 cm</td>
</tr>
<tr>
<td>Zohdi &amp; El Kheshin, 2006</td>
<td>18</td>
<td>Kocher point</td>
<td>3 cm</td>
</tr>
<tr>
<td>Acerbi et al., 2007</td>
<td>6</td>
<td>11 cm pst to nasion</td>
<td>3 cm</td>
</tr>
<tr>
<td>Levine et al., 2007</td>
<td>35</td>
<td>1 cm ant to CS</td>
<td>5 cm</td>
</tr>
<tr>
<td>Greenlee et al., 2008</td>
<td>35</td>
<td>8 cm pst to nasion</td>
<td>7 cm</td>
</tr>
<tr>
<td>Mishra et al., 2010</td>
<td>59</td>
<td>4 cm ant to CS</td>
<td>4–5 cm</td>
</tr>
<tr>
<td>Boogaarts et al., 2011*</td>
<td>85</td>
<td>1 cm ant to CS</td>
<td>4–5 cm</td>
</tr>
<tr>
<td>Delitala et al., 2011</td>
<td>7</td>
<td>1.5 cm above orbital rim</td>
<td>midpupillary line</td>
</tr>
</tbody>
</table>

* Ant = anterior; CS = coronal suture; pst = posterior; sup = superior.

Interestingly, the location of the entry point relative to the coronal suture appears to be unaffected by the size of the ventricles ($r = 0.036, p = 0.827$). In addition to the ratio of FH/ID, we realized that the variability of the optimal entry point and trajectory may change with other parameters, such as the size of the lesion and its location in the third ventricle. Although the colloid cyst is classically thought to be in the anterior third ventricle, its actual location may be altered to some extent from patient to patient. The ultimate selection of the “ideal” entry and trajectory should be on a case-by-case basis. It will be better achieved with Stealth navigation image guidance. The ideal entry point is useful because neuronavigation is not universally available, especially in smaller centers and developing countries.

New techniques and outcomes of ECC resection previously reported by our group had demonstrated a significantly lower incidence of cyst recurrence. One of the principal factors that has contributed is the use of the anterolateral approach that allows a direct view of the attachment point of the cyst on the roof of the third ventricle. The anterolateral approach provides a significant advantage over the traditional Kocher point approach (3 cm lateral to midline and 1 cm anterior to the coronal suture). From the Kocher point one sees the fornix from above and the colloid cyst wall obliquely. A rigid endoscope cannot offer a direct view of the cyst attachment without injury of the fornix. An anterolateral entry point offers a more perpendicular approach to the foramen of Monro, and the fornix can be preserved. If the working channel is maintained superiorly, the cyst attachment at the roof of the third ventricle can be easily dissected and inspected for residual cyst with no need of fornix manipulation. The head of the caudate nucleus is the lateral limit of our approach. In patients with ventriculomegaly this can be as far as 7 cm lateral to midline. Every effort is made to achieve the most lateral trajectory without passing through the head of the caudate nucleus. The consequences of caudate injury are unknown.

The current study has some weaknesses. All the entry points and trajectories were analyzed on the right side. We did not evaluate clinical results, including neuropsychological outcomes. The sole purpose was to assess the ideal entry points that should have been used while taking into account the surgical and anatomical priorities we identified. We also recognize that the ideal entry point and trajectory have to be modified based on factors unique to a specific patient, such as the presence of a ventriculoperitoneal shunt or previous bur hole. In some cases, the foramen of Monro is smaller than the outside diameter of the endoscope and may need to be stretched somewhat. If so, it is more essential to locate the ideal trajectory exactly at the center of the foramen.

Conclusions

The present study suggests that the optimal entry for ECC excision be located $42.3 \pm 11.7$ mm perpendicular to the midline, and $46.9 \pm 5.7$ mm anterior to the coronal suture, but also that this point differs with the size of the ventricles. Given the large variation of the “ideal” entry point laterally from the midline and of the trajectory from patient to patient, we propose that intraoperative stereotactic navigation should be considered for all ECC procedures whenever it is available. If intraoperative neuronavigation is not available, the entry point should be estimated from the patient’s own preoperative imaging studies. An estimated entry point of 4 cm perpendicular to the midline and 4.5 cm anterior to the coronal suture is an acceptable entry point alternative that can be used in patients with ventriculomegaly.

Disclosure

Dr. Nakaji is a consultant for Medtronic Surgical Technologies. Author contributions to the study and manuscript preparation include the following. Conception and design: Rangel-Castilla,
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