Retractless Transvermian versus Telovelar Approach for Excision of Pediatric Fourth Ventricular Tumors: Surgical Technique, Clinical Outcome and Cerebellar Mutism

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ARTICLE INFO

Received: 25 February 2015
Accepted: 9 April 2015

Key words: Telovelar, Transvermian, Fourth ventricular tumors, Mutism

ABSTRACT

Background: Tumors of the fourth ventricle are always challenging due to the difficulty of its access as well as the complexity of eloquent nearby neural structures. Objective: To compare transvermian and telovelar approaches regarding the safety of the technique, the feasibility of total tumor resection, clinical outcome and relation to postoperative cerebellar mutism. Patients and Methods: A prospective study including forty pediatric patients having fourth ventricular tumors, patients were classified equally into two groups; Group I: 20 patients operated upon by retractless transvermian approach, Group II: 20 patients operated upon via telovelar approach. All patients were hydrocephalic and were subjected to ventriculoperitoneal shunt placement except eight cases did endoscopic third ventriculostomy (five and three cases of groups I and II respectively) 2-5 days prior to the definitive posterior fossa surgery. Patients were followed clinically and radiologically on 3 months intervals postoperatively, for a mean period of 12 months. Results: In groups I and II respectively; gross total tumor excision was achieved in eighteen (90%) and seventeen patients (85%). Excellent and good clinical outcome immediately postoperative were noted in fourteen (70%) and thirteen patients (65%), and increased to 90% of each group at twelve months interval. Complication rates were 25% and 30% (five and six cases), postoperative cerebellar mutism was encountered in three (15%) and four patients (20%), mutism recovered in all cases within 2-6 weeks. Tumor recurrence recorded in three (15%) and one patient (5%). A single mortality case in this series (of group II – 5%) didn’t survive the sequelae of postoperative haematoma. Conclusion: Both transvermian (without sustained retraction) and telovelar approaches have no significant difference in safety, feasibility of total tumor excision, clinical outcome, postoperative complications and cerebellar mutism. The choice of either approach depends mainly on the surgeon's skills and preference. Telovelar approach is generally preferred. However, retractless tranvermian route is recommended for large tumors extending to the rostral fourth ventricle.

INTRODUCTION

The surgical access to the fourth ventricular tumors was and remains challenging for neurosurgeons. This is attributed to the complexity of eloquent nearby neural structures like brain stem, lower cranial nerves and cerebellar peduncles. Traditionally, transcortical access to the fourth ventricle has been the approach of choice (transvermian approach), this is achieved by splitting the cerebellar vermis and/or partial resection of cerebellar hemisphere followed by sustained lateral retraction of both cerebellar hemispheres. However, the approach involves injury of normal cerebellar tissue in addition to the effect of lateral retraction on the dentate nuclei which was suggested by many authors as a contributing factor to postoperative cerebellar mutism as well as poor clinical outcome.

The telovelar approach was first described by Matsushima et al. The approach involves the access to the fourth ventricle through the cerebello-medullary fissure with opening of the tela choroidea and the inferior medullary velum which offers a natural corridor in between normal neural tissues, thus avoiding unnecessary neural injury. However, the approach still offers limited access to the aqueductal region high up in the fourth ventricle as well as to its lateral recesses which requires extra manipulation by different ipsilateral and contralateral retractions of cerebellar
tonsils to provide better views for working at different angles of the fourth ventricle.\textsuperscript{4,14,20}

The aim of this study is to compare the results of both approaches regarding the safety of technique, the feasibility of total tumor resection with different pathological types, clinical outcome and relation to postoperative cerebellar mutism. Provided that all cases operated upon by transvermian approach had no constant retraction throughout surgery.

**PATIENTS AND METHODS**

This is a prospective study conducted on forty cases of pediatric ventricular tumors admitted to Children's Cancer Hospital Egypt CCHE and Specialized pediatric university hospital (Abul Reesh) between January 2009 and December 2012.

**Patients were divided into two groups:**
- Group I: twenty patients operated upon by retractless transvermian approach,
- Group II: twenty patients operated upon via telovelar approach.

All patients were fully investigated by proper history taking, full general and neurological examination. CT brain was performed on admission for assessment of associated hydrocephalus.

All patients included in this study presented with hydrocephalus and were subjected to cerebrospinal fluid (CSF) diversion prior to posterior fossa surgery, five patients (25%) of group I had ETV while the other 15 patients (75%) had ventriculo-peritoneal (V-P) shunt placement. In group II, ETV was performed in three patients (15%). MRI of the brain and whole spine were then performed and patients were prepared for surgery.

Posterior fossa surgery was performed after CSF diversion by 2 – 5 days.

**Operative technique**

Patients were operated upon in prone position, with head fixed by three point fixation. Maximum allowed head flexion was done limited by any airway compression or venous engorgement possibilities. The head was then elevated for 15–20° (concord position).

Linear skin incision starting 1 cm above the inion and extending down to the level of C2 was done, followed by midline splitting of the fascia and muscles, then muscle separation and lateral retraction were done exposing the bony limits of the posterior fossa and posterior arch of atlas vertebra ± extending down to C2 or C3 if the tumor extends below the level of foramen magnum.

Suboccipital craniotomy was started just below the edge of the transverse sinus and extended bilaterally in caudal direction to include the posterior edge of foramen magnum, the posterior arch of C1 was excised routinely. The dura of the posterior fossa was incised in a Y-shaped manner, reflected upwards and laterally at the level of foramen magnum. The cisterna magna is sharply incised and drained to partially release the pressure within the posterior fossa, the arachnoid overlying the tumor and/or the cerebellar tonsils was dissected (Fig.1a).

In group I, midline vermian incision (0.5-1.5) was performed (Fig.1b), this was followed by inspection of the tumor boundaries. No retractors were applied throughout surgery. Tumor debulking is then started using bipolar suction technique alternating with the use of CUSA (cavitron ultrasonic surgical aspirator) with the suction tube used for intermittent gentle retraction throughout surgery (Fig.1c,d).

In group II, the cerebello-medullary fissure was identified between the medulla and cerebellar tonsils. One tonsil is gently retracted in a superolateral direction. The tela chooroidea is incised between the uvula and the cerebellar tonsils starting inferiorly near the foramen of Magendie and extending up through the inferior medullary velum providing access to the lateral recess. Not all the previous steps were followed in every case, just the idea of the approach was performed according the size and nature of the tumour. The vermis is retracted upwards protected by a cottonoid then the tumour debulking is started in the same manner as for group I. (Fig.1e)

After tumour excision, proper haemostasis and inspection of the floor of the fourth ventricle and the lower opening of the aqueduct of Sylvius is performed (Fig.1f). The dura was closed with interrupted sutures followed by re-placing of the craniotomy flap, then the wound is closed in layers.

Patients were admitted to the ICU for at least 24 hours. MRI with gadolinium was performed within 48 hours following surgery to assess the extent of tumor resection, presence of any hematomata or edema.

The immediate postoperative clinical outcome was carefully assessed and recorded according to our postulated scale:
- Excellent: Complete improvement of symptoms,
- Good: Stationary course or mild improvement,
- Poor: Deterioration of preoperative symptoms or development of new ones.

All patients were followed clinically and radiologically on 3 months intervals postoperatively, for a mean period of 12 months.

**Statistical methods**

Data management and statistical analysis were performed using Statistical Package for Social Sciences (SPSS) vs. 21.

Numerical data were summarized using means and standard deviations or medians and ranges. Categorical data were summarized as percentages. Comparisons between the 2 groups with respect to normally distributed numeric variables were done using the t-test. Non normally distributed numeric variables were compared by Mann-Whitney test. For categorical variables, differences were analyzed with \( \chi^2 \) (chi square) test and Fisher’s exact test when appropriate.
All p-values were two-sided. P-values < 0.05 were considered significant.

**RESULTS**

This study included forty pediatric patients and classified according to the surgical approach into 2 groups (20 patients each) as follows:

- **Group I**: Transvermian approach,
- **Group II**: Telovelar approach.

Patients were thirteen males and seven females with mean age of 7.3 years in group I, eleven males and nine females, mean age 5.6 years in group II (Table 1).

<table>
<thead>
<tr>
<th>Table 1: Age and gender of patients</th>
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</thead>
<tbody>
<tr>
<td><strong>Age (yrs.)</strong></td>
</tr>
<tr>
<td>Mean ±SD</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
</tbody>
</table>

*p<0.05 is considered significant

Clinical presentation of the patients (Table 2) revealed the presence of hydrocephalus in all forty patients (100%). ETV was performed for five patients of group I (25%) and three patients of group II (15%) while the remaining patients had V-P shunt placement.

Visual affection was noted in twelve patients (five (25%) in group I, seven (35%) in group II) in the form of blurring of vision, diminution of visual acuity resulting from the increased intracranial pressure (ICP).

Long tract affection in the form of weakness, hemiparesis, spasticity and upper motor affection signs was noted in five patients (three (15%) in group I, two (10%) in group II).

Cerebellar manifestations were recorded in ten patients (six (30%) in group I, four (20%) in group II) in form of ataxic gait, discoordination of movements and nystagmus.

**Fig. 1 a-f:** a: Arachnoid dissection around the tumor. b: Vermian incision in transvermian approach. c: Tumor aspiration with CUSA (no retraction). d: Suction bipolar tumor removal (no retraction). e: Vermian retraction in telovelar approach; f: Clear fourth ventricular floor and aqueductal opening after tumor excision.
Table 2: Clinical presentation and duration of symptoms

<table>
<thead>
<tr>
<th>Clinical presentation</th>
<th>Transvermian approach n=20(%)</th>
<th>Telovelar approach n=20(%)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocephalus</td>
<td>20(100)</td>
<td>20(100)</td>
<td>1.000</td>
</tr>
<tr>
<td>Visual dysfunction</td>
<td>5(25.0)</td>
<td>7(35.0)</td>
<td>0.490</td>
</tr>
<tr>
<td>Long tract affection</td>
<td>3(15.0)</td>
<td>2(10.0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Cerebellar manifestations</td>
<td>6(30.0)</td>
<td>4(20.0)</td>
<td>0.465</td>
</tr>
<tr>
<td><strong>Duration of symptoms (months)</strong></td>
<td><strong>Median (range)</strong></td>
<td><strong>Median (range)</strong></td>
<td><strong>P value</strong>*</td>
</tr>
<tr>
<td></td>
<td>6.0(0.5-20.0)</td>
<td>3.5(0.25-14.0)</td>
<td>0.201</td>
</tr>
</tbody>
</table>

*p<0.05 is considered significant

Enhanced MRI of the brain was performed within 48 hours postoperatively to assess the extent of tumor resection (Fig. 2 and 3). Gross total resection (GTR) was achieved in 90% of the cases in group I and 85% of patients in group II (Fig. 4).

Fig. 2 a-f: a-c: Preoperative MRI of 7 years old female with fourth ventricular medulloblastoma. d-f: postoperative MRI after gross total resection via telovelar approach.
Fig. 3 a-f: a-c: Preoperative MRI of 3 years old male with fourth ventricular G II ependymoma. d-f: Postoperative MRI after gross total resection via retractless transvermian approach

Fig. 4: Extent of tumor resection in both groups

Subtotal resection (STR) was done in two patients of group I, this was due to brain stem involvement in one patient with anaplastic ependymoma and excessive bleeding in the other patient with anaplastic medulloblastoma.

In group II, subtotal resection was performed in three patients, two of them were anaplastic ependymomas with diffuse brain stem attachment while the third case was pilomyxoid astrocytoma who had severe intraoperative bradycardia on trial of total resection. All residual tumor portions were less than 2 cm³ of volume as determined by enhanced postoperative MRI.

Pathological examination of tumours revealed medulloblastoma predominance and ependymomas came next (Fig. 5).
The clinical outcome of the two groups was regularly followed up every 3 months. The results were recorded and compared immediately postoperative, at 3 and 12 months follow up intervals (Table 3). Excellent and good outcomes were achieved in fourteen patients (70%) of group I and thirteen patients (65%) of group II immediately postoperative, which increased to 90% (eighteen cases) in each group at the end of a year of follow up. Poor outcome was encountered in six cases (30%) of group I and seven cases (35%) of group II postoperatively. At 12 months follow up interval, poor outcome was noted in two cases (10%) of group I and one case (5%) of group II.

### Table 3: Clinical outcome during a year of follow up

<table>
<thead>
<tr>
<th>Clinical outcome</th>
<th>Transvermian approach n=20(%)</th>
<th>Telovelar approach n=20(%)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Immediate post-operative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>7(35.0)</td>
<td>3(15.0)</td>
<td>0.332</td>
</tr>
<tr>
<td>Good</td>
<td>7(35.0)</td>
<td>10(50.0)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>6(30.0)</td>
<td>7(35.0)</td>
<td></td>
</tr>
<tr>
<td><strong>3months postoperative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>9(45.0)</td>
<td>10(52.6)</td>
<td>0.241</td>
</tr>
<tr>
<td>Good</td>
<td>7(35.0)</td>
<td>6(31.6)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>4(20.0)</td>
<td>3(15.7)</td>
<td></td>
</tr>
<tr>
<td><strong>1 year postoperative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>16(80.0)</td>
<td>13(68.4)</td>
<td>0.222</td>
</tr>
<tr>
<td>Good</td>
<td>2(10.0)</td>
<td>5(26.3)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>2(10.0)</td>
<td>1(5.3)</td>
<td></td>
</tr>
</tbody>
</table>

* one patient died in group II (n=19)
Throughout the first postoperative year, clinical outcome showed no statistically significant difference between the 2 groups.

Complication were encountered in five patients of group I (25%) and six patients of group II (30%) in the form of weakness, transient bulbar palsy, disturbed conscious level or postoperative hematoma (Table 4) and showed statistically insignificant difference between both groups.

At six months postoperatively, in group I, weakness completely recovered in one patient while the other two patients had residual weakness; in group II, only one of the four patients with postoperative weakness had poor outcome.

All the three patients with transient bulbar palsy were fully recovered in 2 – 6 weeks interval.

<table>
<thead>
<tr>
<th>Complications</th>
<th>Transvermian approach</th>
<th>Telovelar approach</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications occurrence</td>
<td>5(25.0)</td>
<td>6(30.0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Weakness</td>
<td>3(15.0)</td>
<td>4(20.0)</td>
<td>0.677</td>
</tr>
<tr>
<td>Bulbar palsy</td>
<td>2(10.0)</td>
<td>1(5.0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Disturbed conscious level</td>
<td>2(10.0)</td>
<td>2(10.0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Postoperative hematoma</td>
<td>0</td>
<td>1(5.0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Recurrence</td>
<td>3(15.0)</td>
<td>1(5.0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Mortality</td>
<td>0</td>
<td>1(5.0)</td>
<td>1.000</td>
</tr>
</tbody>
</table>

* Patients had more than one of complications

Four patients (two of each group) had disturbed conscious level which showed full recovery at 3 months follow up interval in three of them. The fourth patient was of group II presented the only mortality case in this study. This was a 4 years old male with anaplastic medulloblastoma, excessive intraoperative bleeding occurred and the procedure stopped before total resection. The patient had posterior fossa hematoma 12 hours postoperatively with marked deterioration of his conscious level. The hematoma was surgically evacuated with no subsequent clinical improvement. The patient died 5 days later from cardiac and respiratory failure.

Recurrence of tumor and/or regrowth was noted in four patients (three (15%) in group I, one (5%) in group II) at 9–12 months postoperative interval, all were medulloblastoma (one had STR) and were candidates for chemotherapy with no reoperation needed.

Postoperative cerebellar mutism occurred in seven cases, three of group I (15%) and four of group II (20%), mutism started 1–5 days postoperatively, all patients recovered within 2–6 weeks with residual ataxia in one patient and dysarthria in another patient of group I, both completely recovered at 6 months follow up interval. Group II had residual ataxia in two of the four patients with postoperative mutism, both were fully recovered at 6 months follow up (Table 5). Two of the three patients of group I developing mutism had totally resected medulloblastoma while the third case was subtotaly resected anaplastic ependymoma. The four patients of group II had two medulloblastomas, ependymoma and astrocytoma, all were totally resected.

It was apparent that cerebellar mutism was not significantly affected by either approaches, the pathological type or extent of tumor resection.

<table>
<thead>
<tr>
<th>Mutism</th>
<th>Transvermian approach</th>
<th>Telovelar approach</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onset (post-operative days)</td>
<td>3(15.0)</td>
<td>4(20.0)</td>
<td>1.000</td>
</tr>
<tr>
<td>Median (range)</td>
<td>2(1-3)</td>
<td>3(1-5)</td>
<td>0.696</td>
</tr>
<tr>
<td>Duration (weeks)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (range)</td>
<td>4(2-6)</td>
<td>3(2-4)</td>
<td>0.812</td>
</tr>
<tr>
<td>Residual symptoms</td>
<td>2(10)</td>
<td>2(10)</td>
<td>1.000</td>
</tr>
</tbody>
</table>
DISCUSSION

Tumors of the fourth ventricle are always challenging to neurosurgeons due to the difficulty of its access as well as the delicate and vital neural tissues in and around this area. 

The transvermian approach had been the widely used route to access fourth ventricular lesions, in which the inferior vermis is incised and the two cerebellar hemispheres are retracted exposing the fourth ventricle inbetween. Dandy in 1945 postulated that vermicinal division would not have any unfavorable sequelae if the dentate nuclei are carefully avoided. However, later studies mentioned a caudal vermian syndrome including disequilibrium, ataxia, nystagmus and discoordination of movement, resulting from vermian injury.

Transient cerebellar mutism was also reported to be associated with vermian incision particularly in pediatric patients. However, great debate is still continued about the relation of postoperative cerebellar mutism (posterior fossa syndrome) and the route of surgery.

These hazards have prompted further search for safer approach to the fourth ventricle through natural planes. Matsushima et al reported the use of the cerebellomedullary fissure as the route of approaching fourth ventricular lesions.

During the last decade or even more, the approach to the fourth ventricular tumors has changed to the telovelar approach without vermian incision, with many reports favouring its minimal invasive nature, proper views of the 4th ventricle with less tissue damage. 

Deshmukh et al noted that the only advantage of the transvermian approach in access to the rostral fourth ventricle is nearly nullified by removal of the posterior arch of C1 in conjunction with the telovelar approach. This provides wider angle for visualization of the rostral portion of the 4th ventricle.

In the current study, both transvermian approach - with no sustained retraction applied throughout surgery- and telovelar approaches were compared regarding surgical access, extent of tumor resectibility, clinical outcome, complication and postoperative cerebellar mutism. Two groups of patients (20 patients each) below the age of 18 years were studied. Group I patients were operated upon by transvermian approach and group II via telovelar approach.

Gross total tumor resection was achieved in 90% and 85% of both groups respectively. Good and excellent clinical outcome rates at 1 year interval for group I and II were 90% in both groups, complications were encountered in 25% and 30% of Group I and II respectively, with a single mortality case in group II.

Post-operative cerebellar mutism was experienced in 15% and 20% of both groups respectively. All cases were transient having median duration of 4 and 3 weeks in the two groups respectively.

The results of this study didn’t show any statistically significant difference between both groups.

Rajesh et al retrospectively studied fifteen pediatric patients with midline 4th ventricular tumors with medulloblastoma predominance. They achieved total excision in fourteen cases (93%) through the telovelar approach. Postoperative neurological deficits were encountered in 46% of patients and cerebellar mutism was noted in two patients (13%). These slightly differ from the results of the current study which is probably attributed to the different sample size as well as different pathological types of tumors. Rajesh et al found that large tumors extending to the rostral 4th ventricle were often difficult to deal with through normal planes, and trials to dissect before tumor debulking may cause more damage. The authors agreed that this approach is difficult to apply with large tumors especially when radical excision is attempted. Postoperative mutism were often related to the surgical technique which may be overcome by staged dissection and decompression, less aggressive retraction and less tissue damage.

Van Calenbergh et al retrospectively analyzed a consecutive series of sixty three patients under the age of 16 years undergoing transvermian posterior fossa surgeries. Cerebellar mutism was noted in five patients (8%) starting in less than 48 hours postoperatively and remaining for a period ranged from 14 to 76 days. In agreement with the current study, Van Calenbergh and colleagues found no statistically significant relation between mutism and age, sex, clinical symptoms, hydrocephalus, large tumor diameter. Only brain stem invasion reached significance at 0.05 level in four of the five patients with postoperative mutism. The authors noted that the anatomical substrate of cerebellar mutism is still unknown. However, most publications suggest the dentate nuclei as a contributing factor and their avoidance during surgery may lower the incidence of postoperative mutism.

Kotil et al reported cerebellar mutism in 30% of medulloblastomas cases (six patients), with brain stem invasion in five of the six patients. They noted that each increase of tumor size by 1 cm means multiplication of odds to develop mutism by 1.53 reaching statistical significance (p < 0.04).

El-Bahy performed telovelar approach to fourth ventricular tumors in sixteen patients with mean age of 20.6 years, total tumor excision rate was 69%, tumors pathology included two meningiomas, one dermoid cyst and one choroid plexus papilloma. No cerebellar mutism was encountered. This is quite different from our results in group II due to the different age groups.
and the pathological tumor types. The author reported the pathological nature of lesions and degree of neural tissue infiltration as the prominent limiting factors in this approach and owed the absence of cerebellar mutism to the use of telovelar instead of transvermian approach.

CONCLUSION

Both transvermian (without sustained retraction) and telovelar approaches have no significant difference in safety, feasibility of total tumor excision, clinical outcome, postoperative complications and cerebellar mutism. The choice of either approach depends mainly on the surgeon's skills and preference. Telovelar approach is generally preferred. However, retractorless transvermian route is recommended for large tumors extending to the rostral fourth ventricle.

REFERENCES