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Surgical approaches: postoperative care and complications "transoral–transpalatopharyngeal approach to the craniocervical junction"

Arnold H. Menezes

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Abstract
Introduction The ventral approach to the craniocervical border has been described for decompression of irreducible extradural pathology. The procedures utilized encompass the transoropharyngeal and median mandibulotomy with glossotomy and the transpalatal procedures. This study was aimed to review the utility of the transoral–transpalatopharyngeal approach.
Clinical materials and methods Seven hundred thirty-three patients underwent transpalatopharyngeal approach for decompression of the brain stem and cervicomedullary junction. Of these, 280 were children below the age of 16 years. The main indication was irreducible ventral pathology compressing the brain stem and cervicomedullary junction. Two hundred two children had irreducible basilar invagination, 28 had proatlas segmentation abnormalities, os odontoideum with a dystopic os odontoideum in 30, and spinal tumors in seven (chordoma, fibrous dysplasia, osteoblastoma). Seven patients with Down's syndrome and irreducible bony compression of the ventral cervicomedullary junction were seen. There were six other miscellaneous diagnoses. All children required craniocervical stabilization which was carried out under the same anesthetic as the transoral procedure.
Operative procedure The procedure entailed fiber-optic intubation. The patient was placed in cervical traction prior to the anterior procedure. The soft palate was split only in individuals with a short clivus with a high riding clivus-odontoid articulation. Craniocervical stabilization was performed in the prone position under the same anesthetic.
Results There was one retropharyngeal infection postoperatively. No cesium fluoride leaks were encountered. Velopalatine incompetence was seen in five children who already had preoperative brain stem dysfunction. Neurological recovery was the rule. Patients who had preoperative syringohydromyelia had resolution of the syrinx on postoperative magnetic resonance imaging.
Discussion The author's technique is described. Since 1977, the procedure has been performed in 732 patients (280 children) and has evolved into a safe and direct approach to the ventral cervicomedullary junction with minimal morbidity and mortality.

A. H. Menezes (✉)
Department of Neurosurgery,
University of Iowa Hospitals and Clinics, 200 Hawkins Drive,
1824 JPP, Iowa City, IA 52242, USA
e-mail: arnold-menezes@uiowa.edu

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Introduction

Abnormalities affecting the craniovertebral junction (CVJ) have been recognized for many centuries with postmortem examinations and a few case reports. The anti-mortem documentation of these lesions has stimulated surgical therapy due to the advances in neurodiagnostic imaging as well as microsurgical instrumentation in the past few decades. Several approaches to the anterior craniovertebral border have been developed. The transoral–transpalatopharyngeal route is the most frequently used for decompression of the ventral cervicomedullary junction (Fig. 1) [1, 2, 5, 7, 9, 10, 14, 23]. A prospective study was initiated at the author's institution in 1977 [14]. Five thousand, three hundred patients have been evaluated since then [17]. A surgical physiological approach to these abnormalities and a decision tree-treatment algorithm were proposed. This is

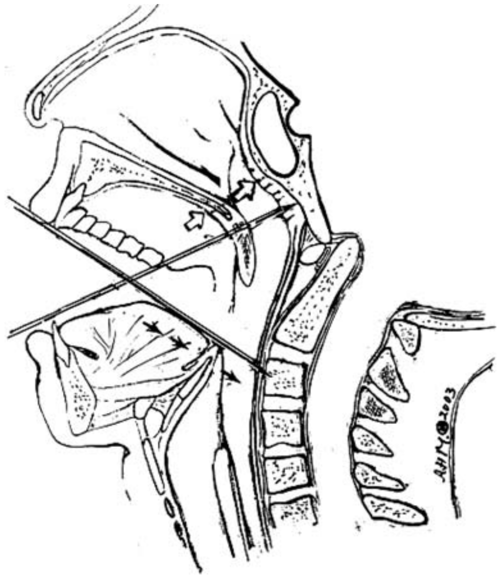

Fig. 1 Author's illustration of exposure to the anterior craniovertebral junction via the transoropharyngeal approach; the *open arrows* signify the exposure when the distal hard palate is excised. The *arrowheads* point to exposure available with median glossotomy

enumerated in the earlier sections of this monograph. Seven hundred thirty-three patients underwent the ventral transoral–transpalatopharyngeal approach since 1977; 280 of these were children below the age of 16 years. A prospective analysis of this group has been made and is reviewed.

Bony abnormalities of the craniocervical junction are divided into those that are reducible and irreducible [13–15]. Stabilization is the primary treatment for reducible lesions [4, 16, 20, 22]. Surgical decompression is necessary when irreducible pathology is encountered [5, 11]. This decompression is made in the direction in which the encroachment has occurred [16]. Thus, the transoral–transpalatopharyngeal route is utilized when a lesion is ventrally situated. The other possible approaches to the CVJ are the lateral extrapharyngeal route and the maxillary dropdown procedures [11, 18]. If instability occurs in any situation, it is mandated that posterior fixation is made.

Clinical material and methods

Preoperative assessment

Computed tomography (CT) of the CVJ is an integral part of the assessment of the bony pathology [15, 24]. Conventional CT was augmented by three-dimensional CT reconstructions. This was to identify the location of the occipital condyles, the lateral atlantal and axis masses and the odontoid process. It also provides a "road map" for the treating surgeon. Magnetic resonance imaging (MRI) is the mainstay of the neurodiagnostic armamentarium (Fig. 2). T1- and T2-weighted midsagittal MRIs were obtained with the flexed and extended position. This modality provided information about the neural structures and their relationship to the osseous abnormality and vascularity. MR angiography was performed when there was neurological

Fig. 2 Composite of midsagittal T2- and T1-weighted MRI of CVJ and cervical spine; the clivus-odontoid articulation indents into the medulla. Note the hindbrain herniation and cervical syringohydromyelia. This 8-year old presented with brain stem dysfunction and myelopathy

dysfunction which could not be explained. It was also obtained with the patients in the flexed and extended position as well as in a rotated position to identify if vascular occlusions occurred when the patient changed position. An attempt at "reduction" was made in children. This is because 80% of children with atlantoaxial dislocation or basilar invagination below the age of 12–14 years could be reduced and relieve compression on the neural structures and, thus, avoid the ventral procedure [12, 15]. When a reducible lesion was documented, stabilization was the operation provided.

Assessment of nutritional status, dental hygiene, and comorbidities

This issue is particularly important in children who have had difficulty in swallowing as well as failure to thrive. Brain stem involvement and lower cranial nerve dysfunction was felt to affect the nutritional status. In these patients, preoperative nutritional support was provided. It was felt that failure to do so could result in wound dehiscence and also nonfusion.

Dental hygiene was addressed to remove causes of bacterial contamination such as dental caries and gingivitis in the operative field. Dental guards were provided to protect the upper and lower dentition during surgery.

Abnormalities of the brain stem and lower cranial nerves (cranial nerves IX, X, and XII) were evaluated and its effects on the pulmonary function documented. Sleep apnea was likewise documented. Loss of vagal, hypoglossal, and glossopharyngeal nerve function mandated a tracheostomy at the start of the operation in 12 patients.

Oropharyngeal cultures were obtained 4 days prior to the surgical intervention. These were obtained from the nasal passages as well as the oropharynx [17]. No antibiotics were instituted if normal nasal flora was present. As a precaution, Nystatin rinses and Peridex gargles were performed three times a day before the operative procedure. Mupirocin nasal ointment was used in the nasal passages for 2 days prior to the operative procedure.

In some children, the ability to sufficiently open the mouth is extremely limited. A working distance of 2.5–3 cm between the upper and lower incisor teeth is necessary. However, this is further assessed once the child was asleep and paralysis induced by the anesthesiologist. A transmandibular route was essential in only five children and separately described.

Preoperative traction

Skeletal traction is usually applied through an MRI compatible crown halo device to assess the "reducibility of the lesion". The crown-halo traction is usually instituted 4 days before the planned surgical procedures. If the lesion is reducible, dorsal fixation is performed. If it is irreducible, then both the ventral and dorsal procedures are made.

We utilize crown-halo traction in a child between the ages of 8 and 16 years preoperatively. This is performed under mild intravenous sedation and topical and local anesthesia. The child is placed supine with a pad underneath the shoulders and head. A crown halo is positioned just at the equator of the cranium. Pins that are placed above this plane will have a tendency to pull out or entire crown will fall off. The frontal pins were placed 2.5 cm above the supraorbital margin. The retromastoid pins were one on either side. Between the ages 8 and 16 years, a total of four pins were utilized, two on either side. These pins were introduced after local anesthetic and tightened to 6–8 lbs of pressure. In the child between the ages of 4 and 6 years, six to eight pin fixation is used under general anesthesia. Here, the maximum tightening pressure for a 4-year old is 4 lbs and at 6 years of age, four to six pins are used with a pressure of 5–6 lbs. In the young child, the traction is done under general anesthesia.

Preoperative traction, when utilized, is maintained with mild elevation of the head—about 15–20° above the horizontal. Cervical traction is instituted at 5–6 lbs in a young child above the age of 8 years and proceeds onto 9 lbs by the end of the first day. Lateral radiographs are obtained to assess reduction. At the end of 48 h, an MRI is performed with the patient in cervical traction to assess the neural–osseous relationships and reduction. In the child in whom an operative procedure is being done for a tumor or a non-congenital abnormality, the crown-halo traction was applied intraoperatively.

Operative technique

Indications

The ventral transoral–transpalatopharyngeal route to the craniocervical border was felt to be indicated in irreducible ventral bony abnormalities associated with compression of the cervicomedullary junction. This approach is also reserved for extradural bony and soft tissue masses and a few intracranial intradural tumors. With elevation of the soft palate, it is possible to expose the inferior third of the clivus with normal anatomy. However, in congenital pathological states as with a foreshortened clivus or basioccipital hypoplasia, the clivus tends to be more horizontally located than vertical. Thus, it becomes essential to split the soft palate and resect the posterior inferior portion of the posterior hard palate to gain exposure. In this manner, the upper portion of the clivus can be visualized. The inferior extent of the exposure, which is limited by the degree of depression of the tongue, is the C2–C3 interspace.

A median glossotomy with mandibulotomy, when utilized, allows for caudal exposure to the C4 vertebral body [6, 8, 17, 25]. The lateral extent of the exposure is between the condylar canals of the hypoglossal nerve, the Eustachian tubes, and the vertebral arteries before they enter into the intradural space. This limits the lateral exposure. However, when a tumor, such as a chordoma, was present, this had created the dissection and the exposure.

Operative procedure

The children were brought to the operating theater with a cervical collar in place as a precaution during intubation, maneuvers, and positioning. In the older child between the ages 10 and 15 years, an awake fiber-optic oral endotracheal intubation was performed. However, if it was felt that the child could not tolerate the procedure, general anesthesia was utilized following which the fiber-optic intubation was carried out through the mask.

The child was positioned supine on the operating table with traction being maintained at 5–7 lbs. The endotracheal tube was secured to the skin overlying the mandible and the nasal passages anesthetized with topical cocaine. A throat pack was used to occlude the laryngopharynx and oral preparation carried out with 10% povidone-iodine and hydrogen peroxide.

The Dingman mouth retractor was used for automatic exposure incorporating the tongue blade. This provided self-retaining exposure of the oral cavity and the oropharynx (Fig. 3a).

The soft palate was split in procedures that involved the foramen magnum and the inferior clivus (Fig. 3b). At times, it was also necessary to remove a portion of the hard palate to gain exposure of the high nasopharynx.

Large adenoid tissue in the nasopharynx, at times, required their removal. The posterior pharyngeal wall was

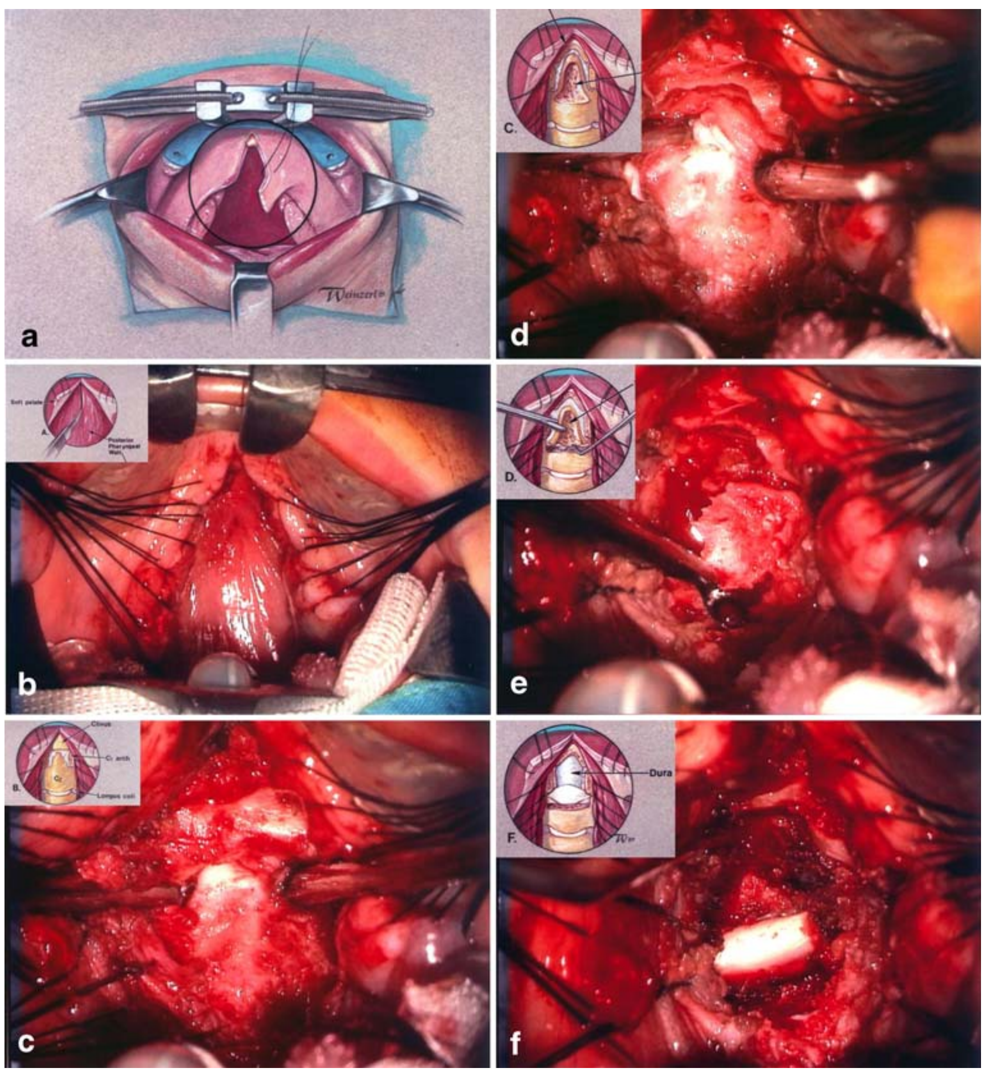

Fig. 3 **a** Artist's illustration of the transoral approach: the Dingman mouth retractor is in place with the tongue depressor. The soft palate has been incised. The operation with the microscope will be carried out within the *circle*. **b** The soft palate has been divided. The posterior pharyngeal is being made. **c** The anterior arch of C1 and the base of the odontoid process is seen. **d** The anterior arch of the atlas is removed. The odontoid is being cored out. **e** The shell of the cored out odontoid is being removed. **f** The tectorial membrane is decompressed. The transverse cruciate ligament is seen as a bright yellow structure

topically anesthetized and incised, and the leaves of the pharyngeal wall were retracted laterally. The longus colli muscles and longus capitis were detached from their medial origin on the ventral surface of the cervical vertebra. The procedure was carried out under the operating microscope and at high power. The anterior arch of the atlas was resected for 15 mm in the midline and the odontoid cored out (Fig. 3c). The shell of the odontoid process was removed (Fig. 3d). In situations where the problem was more complex with proatlas segmentation abnormalities, these abnormal bony protuberances were excised. Our procedures were carried out with a high-speed electric drill and Diamond burrs.

The inferior portion of the clivus was removed when indicated using Diamond burr and fine Kerrison rongeurs. The odontoid process removal proceeded into the body of the axis based on the preoperative diagnostic studies, which were referred to during the procedure (Fig. 3e). The lateral extent of the exposure is dictated by the amount of decompression required by the preoperative neurodiagnostic images.

The cruciate ligament was usually visualized with the end of the bony removal.

During the operation, cervical traction was maintained for inherent, potential, or iatrogenic instability. The tectorial membrane was not removed after the first 30 patients. The pannus produced by the instability was encountered around the odontoid process and was excised after bipolar cauterization and piecemeal removal.

The completion of decompression and resection was heralded by the visualization of the tectorial membrane and the dura as well as the cruciate ligament inferiorly (Fig. 3f). Aerobic and anaerobic cultures were obtained, and bacitracin powder was utilized in the wound. The longus colli and longus capitis muscles were approximated and, subsequently, the posterior pharyngeal musculature and the posterior pharyngeal mucosa. A nasogastric tube was implanted for postoperative nutritional care. The soft palate was closed in two layers.

Dorsal occipitocervical fusion combined with posterior fossa decompression was usually mandated and performed during the same anesthetic.

Nasogastric tube feedings were maintained for the first 5 days. A clear liquid diet was, then, started. Over several days, it was advanced to a full liquid diet and, subsequently, to a soft diet.

Postoperatively, the endotracheal intubation was maintained until swelling of the oral tissues, including the tongue, had receded. The tube was left in place 3 to 4 days in most children.

In the event that the dura was opened, intravenous antibiotics (cefotaxime, Flagyl, and methicillin) and spinal drainage is maintained for 10 days after the operation. This was not encountered in any of the children.

In the earlier part of the series, children who had undergone a dorsal fixation after the anterior procedure were ambulated in a halo vest. At the present time, this is done with a custom-fitted occipitocervical Minerva-type

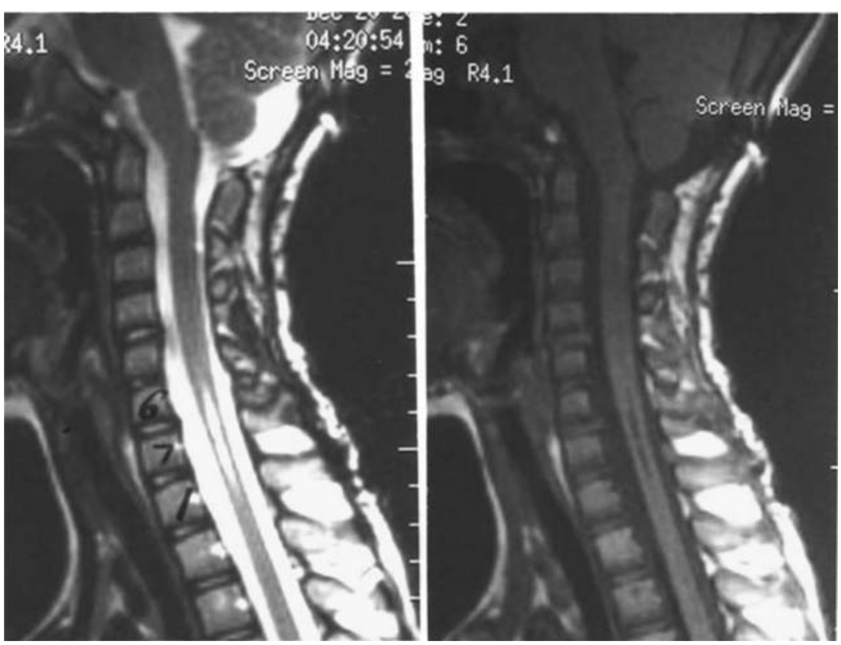

Fig. 4 Composite of T2 (*left*) and T1 (*right*) midsagittal MRI of CVJ and cervical spine done postoperatively (same patient as in Fig. 2) after a transpalatopharyngeal decompression of the ventral medulla. Note the decompression as well as reduction in the syrinx. The child had neurological recovery

brace or an Aspen-Minerva brace. This necessitated 4 to 6 months of craniocervical immobilization.

Results

Neurological improvement was seen in all children. Six children who were ventilatory dependent prior to the operation, following previous primary posterior fossa decompressions or trauma, had resolution of their neurological symptoms and signs [11–13, 17, 19]. Downbeat nystagmus, brain stem dysfunction, and cranial nerve palsies as well as sleep apnea were prominent in children with basilar invagination and the associated hindbrain herniation. These signs regressed following the ventral procedure (Fig. 4).

Complications

There was no episode of meningitis or CSF leak, and lumboperitoneal shunting was never required as in some series [23].

A pharyngeal wound dehiscence occurred in two children. In the first, a Yankour suction was inappropriately handled by the patient reopening the pharyngeal wound at the end of 10 days. In another child, a retropharyngeal infection was caused by Bacteroides. This was treated with intravenous antibiotics and drainage into the pharynx. Intravenous hyperalimentation was necessary for 2 weeks. This occurred prior to 1990. Following the treatment of the infection, a dorsal fixation was made.

Velopalatine incompetence was encountered in five children. This was a particular problem seen in the young individual and usually occurred 3 to 6 months after the transoral operation, where the palate had been split. It was felt to be secondary to fibrosis that took place in the soft palate or in the pharyngeal wall. Endoscopy identified the cause. Pharyngeal retraining in three children and an obturator in the other two circumvented the problem. In one child, fat emulsion was injected into the posterior pharyngeal wall to bring it forward and close off the incompetence. This had to be repeated on two occasions.

There were no deaths.

Discussion

The transoral approach to the posterior pharyngeal wall has been an operation that was initially used for drainage of retropharyngeal abscesses. Although this route provides direct access to the craniovertebral junction, it has only now gained its well-deserved place in the neurosurgical armamentarium. The reasons for this have been initial reports of infection, limited exposure, unacceptable patient morbidity and mortality, and cerebrospinal fluid leakage [1, 2, 7, 9, 23]. We feel that this series has shown that the ventral transoral–transpalatopharyngeal approach to the lower clivus and the upper cervical spine is safe, rapid, and effective. It is important in relieving ventral irreducible pathology of the craniovertebral junction (Table 1).

There have been recent attempts at obtaining better visualization and reducing the surgical morbidity with endoscopically assisted procedures [21, 26]. This author has not felt the need for any of those. In addition, intraoperative fluoroscopy or the use of “Stealth technology” has been of little value in our hands because of the marked improvement in the three-dimensional imaging.

The advantages of the transoral-transpalatine approach to the craniocervical region compared with other operative approaches in irreducible pathology is that: (1) the impinging bony pathology and granulation tissue that accompanies chronic instability is easily accessible, (2) the child is placed in the extended position as opposed to the flexed position, thus, decreasing the angulation on the brain stem during surgery, and (3) surgery is performed through the avascular median raphe and through the clivus. Reports of using the far lateral-transcondylar approach to remove the odontoid process and ventral pathology in front of the brain stem is, by itself, significantly stabilizing.

The indications for the transoral operation at the anterior craniocervical border have to be fairly exact. A precise definition of the pathology usually requires more than one radiographic procedure [3, 16]. Merely identifying the ventral pathology without attempts at reduction is not considered as grounds for an operative procedure. The primary approach to intra-arachnoid lesions at foramen magnum is not the transoral route unless other approaches prove ineffective.

The hindbrain herniation (Chiari I) was identified in 60% of the children who underwent a transoral operation. Several of these children had undergone a previous primary operation consisting of posterior fossa and upper cervical

Table 1 Pathology encountered at the ventral craniocervical junction in 280 children using the transoral–transpalatopharyngeal approach

Pathology	Number
Basilar invagination	202
Proatlas segmentation abnormalities	28
Os odontoideum–dystopic os odontoideum with invaginating axis vertebral body	30
Tumors (chordoma, fibrous dysplasia, osteoblastoma)	7
Down’s syndrome	7
Miscellaneous	6
TOTAL	280

canal decompression. Rapid deterioration ensued in these children or an initial improvement was followed by progressive neurological deterioration. MRI in each of these instances showed an increase in the ventral cervicomedullary junction compression and the angulation secondary to the peg-like basilar invagination. A complicating feature is cerebellar slump after a newly created wide posterior fossa decompression, and this further worsens the situation as well as causes further impaction at foramen magnum. The improvement after ventral decompression is attributable to relief of brain stem angulation, improved blood supply, or changes in cerebrospinal fluid pressure dynamics. We have shown that anterior craniovertebral bony decompression resulted in relief of the brain stem and cerebellar symptoms including resolution of syringohydromyelia.

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