The Effect of Intravelar Veloplasty on Velopharyngeal Competence Following Pharyngeal Flap Surgery

BENNIE L. JARVIS, M.D.
WILLIAM C. TRIER, M.D.

Clinical experience from primary palatoplasty and studies of velopharyngeal valving suggest that intravelar veloplasty (IVVP) could increase the achievement of velopharyngeal competence in patients undergoing pharyngeal flap surgery. In order to test this hypothesis, a group of 91 patients undergoing superiorly based, high-attached, lined pharyngeal flaps along with intravelar veloplasty were compared retrospectively with 39 patients who underwent the same procedure without intravelar veloplasty. Comparison of speech evaluation and pressure-flow data demonstrated no difference in attainment of velopharyngeal competence between the two groups. Though theoretically sound, intravelar veloplasty did not appear to improve the results of pharyngeal flap surgery. The high incidence of postoperative hyponasality in both the study and control groups suggests a possible need for increased lateral port size in performing the procedure.

KEY WORDS: *velopharyngeal incompetence, pharyngeal flap, pharyngoplasty, intravelar veloplasty.*

Patients with velopharyngeal inadequacy require structural modification of the velopharyngeal mechanism in order to achieve intelligible, unstigmatized speech. Ideally, the palate serves as a barrier to air, fluid, or sound during speech or swallowing while providing an adequate nasal airway at rest. Many patients with repaired palatal cleft, submucous cleft, or other palatal abnormalities lack an effective dynamic valving orifice between the nasal and oral chamber. Construction of such a valve may be accomplished either with a speech appliance, such as an obturator or palatal lift appliance, or by surgical means.

Many patients with velopharyngeal inadequacy treated with speech appliances eventually achieve adequate velopharyngeal closure despite progressive reduction in size of the obturator, even to the point of eliminating the appliance (Shelton et al, 1967, 1971). Shelton and his co-workers suggested that the appliance served as a stimulus to increase movements of the pharyngeal walls. Blakely (1964) reported the complementary use of speech appliances and pharyngeal flaps, the appliance to increase pharyngeal constriction to the extent needed for effective function of the subsequent pharyngeal flaps. Surgical means of increasing movement of the lateral pharyngeal walls might contribute to improved speech and reduce need for obturator reduction or other therapy intended to increase pharyngeal wall movement. It was hypothesized that lateral pharyngeal wall motion could be enhanced by adding an intravelar veloplasty (IVVP) at the time of pharyngeal flap construction.

A number of studies suggested that IVVP would be expected to accomplish the desired result. First, electromyographic studies (Honjo et al, 1970, 1979) demonstrated that lateral pharyngeal wall motion is primarily the result of levator veli palatini muscle contraction, with secondary contribution from the superior pha-

Dr. Jarvis is a Resident in Otolaryngology at the West Virginia University School of Medicine Morgantown, WV. Dr. Trier is Professor of Surgery in the Division of Plastic Surgery, School of Medicine, at the University of Washington, Seattle, WA.

This paper was presented in part at the Fifth International Congress on Cleft Palate And Related Craniofacial Anomalies, Monte Carlo, Monaco, September 3, 1985.

ryngeal constrictor muscle. Second, the levator muscles in patients with cleft palate insert into the palatal bones rather than into the midline raphe (Fara and Dvorak 1970; Kriens, 1969). This abnormal insertion has also been documented in both overt (Kelley, 1910) and occult (Trier, 1983) submucous cleft palate. Brown et al (1983) and Dreyer and Trier (1984) have reported increased velopharyngeal competency following primary palatoplasty with intravelar veloplasty. And, finally, detachment of the levator veli palatini muscles from their abnormal insertion in cleft palate has been shown to increase lateral pharyngeal wall motion in both overt and submucous cleft palate as evaluated by electrical stimulation (Honjo et al, 1980). It seemed reasonable that IVVP would accomplish the same result in pharyngeal flap surgery. The senior author (WCT), therefore, has included IVVP in performance of pharyngeal flap operations since 1976 upon patients who had not undergone formal IVVP at the time of palatoplasty. The present study attempts to determine whether levator reconstruction improves velopharyngeal closure in patients with pharyngeal flap, as determined by both subjective and objective measures.

Materials and Methods

One hundred thirteen patients at North Carolina Memorial Hospital underwent pharyngeal flap operation by the senior author from 1976 to 1984. The procedure used has been described by Trier (1985). Briefly, the basic pharyngeal flap, as described by Owsley et al (1966), consisted of a wide, superiorly based, high-attached flap lined by posteriorly based flaps of nasal mucous membrane. At the time of dissection, identification of the levator muscles and IVVP were performed.

The records of all patients treated in the Oral Facial and Communicative Disorders Program at the University of North Carolina (OFCDP) undergoing the procedure were reviewed retrospectively. Ninety-one of the 113 patients were followed for 6 months or longer, with a mean length of follow-up of 2.1 years (range 6 months to 6 years). These patients made up the study group. Reasons for loss to follow-up were not documented. Thirty-five percent of the patients had a submucous cleft palate and 8.8% had a congenital palatal incompetence (Table 1); pharyngeal flap was the primary procedure for 86.4% of the patients without overt cleft palate. Of the study patients, 10% had undergone a previous unsuccessful pharyngeal flap procedure, and the inadequate flap was divided and a new pharyngeal flap was constructed at the same time. Closure of an oronasal or oropharyngeal fistula was performed concomitantly on 11 patients (12%). The mean age of the study patients at the time of the pharyngeal flap was 13.27 years (range 2 to 59 years).

TABLE 1 Patients Undergoing Pharyngeal Flap Surgery With Intravelar Veloplasty (July 1976–December 1983)*

Diagnosis	*No.*	*(%)*
Submucous cleft palate	32	(35.2)
Congenital palatal incompetence	8	(8.8)
Unilateral cleft lip and palate	15	(16.5)
Bilateral cleft lip and palate	16	(17.6)
Secondary cleft palate (soft)	10	(11.0)
Secondary cleft palate (complete)	10	(11.0)

* There were 113 patients, with 91 patients followed for 6 months or longer. Mean age at time of procedure was 13.3 years (range 2–56 years).

The study group was compared with two earlier groups of patients that underwent the same pharyngeal flap procedure by the same surgeon (WCT) but without IVVP. One group of 21 patients was treated between 1967 and 1969 at North Carolina Memorial Hospital (Table 2); eight of these patients were excluded from the study because their speech evaluations were missing. A second group of 29 patients underwent the procedure at University Hospital, Arizona Medical Center in Tucson, between 1971 and 1975 (Table 3). Thirty-one percent of the North Carolina (NC) patients and 38% of the Arizona (AZ) patients presented with submu-

TABLE 2 Patients Undergoing Pharyngeal Flap Surgery Without Intravelar Veloplasty (January 1967–July 1969), North Carolina*

Diagnosis	*No.*	*(%)*
Submucous cleft palate	4	(30.8)
Congenital palatal incompetence	0	(0.0)
Unilateral cleft lip and palate	2	(15.4)
Bilateral cleft lip and palate	3	(23.1)
Secondary cleft palate (soft)	2	(15.4)
Secondary cleft palate (complete)	2	(15.4)

* There were 21 patients; data were available on 13 patients. Mean age at time of procedure was 10 years (range 2–17 years).

TABLE 3 Patients Undergoing Pharyngeal Flap Surgery Without Intravelar Veloplasty (September 1971–November 1975), Arizona*

Diagnosis	*No.*	*(%)*
Submucous cleft palate	11	(37.9)
Congenital palatal incompetence	6	(20.7)
Repaired cleft palate	10	(34.5)
Unrepaired cleft secondary palate	1	(3.4)
Palatal palsy	1	(3.4)

* There were 29 patients, with 25 patients followed for 6 months or longer. Mean age at time of procedure was 12 years (range 4–41 years).

cous cleft palate, and an additional 10% of the Arizona group were diagnosed as having congenital palatal incompetence. As in the study group, the decision to perform the pharyngeal flap was based on demonstrable hypernasality and nasal emission. No patient underwent a concomitant procedure. Mean ages at time of operation were similar between the NC and AZ groups (10 and 12 years, respectively). The oldest patient undergoing the procedure in either control group was 18 years.

Outcomes were analyzed by two methods. First, preoperative and the most recent postoperative speech evaluations were compared. NC patients were evaluated by OFCDP speech pathologists; patients were evaluated by speech pathologists AZ in the Department of Speech and Hearing Sciences of the University of Arizona. Parameters noted were hyponasality and hypernasality and the presence or absence of nasal emission. Subjective evaluations of oronasal resonance were recorded during articulation tests at the one-word level and during connected speech. Nasal emission was evaluated using the U-tube water manometer in Arizona and either mirror fogging or the scape-scope Nasal Emission Test in North Carolina. Each parameter was rated using a 6-point scale ranging from absent to severe.

In order to obtain an objective measure of velopharyngeal closure, data from pressure-flow studies were evaluated using the technique developed by Warren (1964). The pressure-flow study provides a calculated measurement of the size of the velopharyngeal orifice during speech based on oral and nasal pressures as well as the rate of nasal airflow. Criteria for adequate closure are based on the finding that velopharyngeal orifices of less than 10 mm^2 are associated with normal speech over 90% of the time, whereas an orifice size above 20 mm^2 is always associated with characteristic cleft palate speech. Between 10 and 20 mm^2 represents borderline velopharyngeal competence. Pressure-flow results were recorded as inadequate, borderline, or adequate.

RESULTS

Over a mean length of follow-up of 2 years, 77 of 91 (84.6%) of the intravelar veloplasty study patients showed demonstrable improvement in achievement or normal vocal resonance and elimination of nasal emission. Patients were considered improved if they demonstrated less post-operative hypernasality or less nasal emission, without an increase in either parameter. Nearly one quarter of the patients (24.2%) exhibited completely normal voice quality, whereas 30.1% of patients still exhibited mild hypernasality or nasal emission. Almost 30%, (29.7%) became hyponasal to some degree (22% mild or mild to moderate, 4.4% moderate, 3.3% moderate to severe) (Table 4). Thus, 76% achieved normal or near-normal speech (with mild hypernasality or hyponasality or mild nasal emission).

Fourteen of the 91 patients (15.4%) either showed no improvement or exhibited increased hypernasality, nasal emission, or both. The most striking characteristic of patients with poor postoperative speech was a greater age at time of operation (25 years versus 13 years). Distribution of diagnoses among these patients was similar to that of the entire group; submucous cleft palate occurred most commonly (28.6%), while 21.4% of the patients presented with bilateral cleft lip and palate, with one or two patients in each of the remaining diagnostic groups.

Postoperative pressure-flow data were available for 72 of the 91 patients, demonstrating

TABLE 4 Postoperative Speech Evaluations of Patients Undergoing Pharyngeal Flap Surgery With Intravelar Veloplasty (1976–1983), North Carolina

Speech Evaluation	*No.*	*(%)*
Within normal limits	22	(24.2)
Mild hyponasality	10	(11.0)
Mild to moderate hyponasality	10	(11.0)
Moderate—severe hyponasality	7	(7.7)
Mild hypernasality/nasal emission	28	(30.1)
Mild to moderate hypernasality/nasal emission	8	(8.8)
Moderate to severe hypernasality/nasal emission	10	(11.0)
Total	95*	(103.8)*

* Note: Total is greater than 100% because four patients with hypernasality also exhibited mild nasal emission.

that 93% of the patients achieved adequate velopharyngeal closure during speech. Two patients (3%) achieved borderline closure, indicating objective improvement in 96% of patients. Twelve of the 14 patients without speech improvement underwent postoperative pressure-flow studies. Velopharyngeal closure was adequate by pressure-flow criteria in seven of these (60%); three of the seven demonstrated adequate closure preoperatively as well. The five patients unable to achieve adequate closure on pressure-flow testing were uniformly older than average at primary repair (19.4 years of age) and at time of flap replacement (45.6 years of age). Four of the five were patients with a previously repaired overt cleft. A forty-eight-year-old Caucasian man with a newly diagnosed submucous cleft palate was the only one of the five patients to achieve near-normal postoperative speech.

The control groups (patients undergoing the pharyngeal flap procedure *without* intravelar veloplasty) consisted of 13 patients between 1967 and 1969 (NC) and of 25 patients between 1971 and 1975 (AZ). Seventy-seven percent of the former group and 92% of the latter group achieved normal or near-normal speech (Table 5). Of note is the finding that hyponasality developed in 7.7% of the NC group and in 16% of the AZ group, with 12% of the latter group requiring revision of the obstructing pharyngeal flaps.

Pressure-flow data were available for only six control patients; velopharyngeal closure was adequate in five of six patients (84%) and borderline in one of six. The patient who did not achieve velopharyngeal competence on pressure-flow testing was an 11-year-old female who had undergone previous repair of a submucous cleft palate at age 6. Although her speech improved, the patient remained mildly hypernasal at last follow-up 2 years postoperatively.

Discussion

These results suggest that IVVP provides no added increase in velopharyngeal adequacy following pharyngeal flap operation despite the theoretical advantage of this procedure. Improvement in velopharyngeal closure was obtained in the control and IVVP groups postoperatively with normal or mildly affected speech obtained in 70 to 80% of each group. Thus IVVP did not demonstrably improve results compared with those in the control group in this study.

Unfortunately, the retrospective nature of the study makes straightforward comparison of the two groups difficult. However, the senior author (WCT) performed, or assisted residents in, the performance of pharyngeal flaps in all patients in the control and study groups. The technique of the operation, including estimation of the dimensions of the lateral ports, was identical in all patients, with the exception that IVVP was performed in the study group. And finally, although the speech pathologists assessing speech prior to and following operation were not the same for all patients, the extent of their experience and their use of measures that focused on oral and nasal resonance balance and the presence or absence of nasal emission suggest reasonable comparability.

Aerodynamic studies were not performed on patients operated upon at the University of Arizona because that technique of objective assessment was not used at that institution. Pressure-flow studies were used routinely, both preoperatively and postoperatively, to assess velopharyngeal function at the University of North Carolina in the control and study groups. These studies were not available for all patients simply because some patients were too young, particularly prior to operation, or because referral for study was inadvertently omitted. In some

TABLE 5 Postoperative Speech Evaluations (Without Intravelar Veloplasty)

	North Carolina (1967–1969)		*Arizona (1971–1975)*	
Speech Evaluation	*No.*	*(%)*	*No.*	*(%)*
Within normal limits	5	(38.5)	17	(68.0)
Mild hyponasality	0	(0.0)	1	(4.0)
Mild to moderate hyponasality	1	(7.7)	0	(0.0)
Moderate to severe hyponasality	1	(7.7)	3	(12.0)
Mild hypernasality/nasal emission	4	(30.8)	2	(8.0)
Mild to moderate hypernasality/nasal emission	1	(7.7)	1	(4.0)
Moderate to severe hypernasality/nasal emission	1	(7.7)	1	(4.0)
Total	13	(100.1)	25	(100.0)

patients, velopharyngeal inadequacy prior to operation was so grossly obvious that aerodynamic studies were deemed superfluous.

Neither videofluoroscopy nor nasendoscopy was used to evaluate patients in either the control or study group. Both techniques demonstrate the quality of velopharyngeal function rather than the degree of velopharyngeal closure. In other words, videofluoroscopy and nasendoscopy can describe the type of velopharyngeal closure, the contribution of lateral pharyngeal wall activity to closure, the extent of posterior pharyngeal wall motion, and the range of palatal motion; however, it cannot judge the quality of speech or the presence or absence of hypernasality or nasal emission. Nor can either technique record the extent of velopharyngeal closure as can pressure-flow techniques. Type or pattern of velopharyngeal closure may be important, however, in other studies that could answer questions relating to palate function.

Although, as noted earlier, there is evidence that IVVP improves rates of velopharyngeal competence for patients undergoing primary palatoplasty. Marsh and colleagues (1986) have not found this to be true in a randomized prospective study in which IVVP was the only apparent variable. Nasendoscopy or videofluoroscopy could determine whether or not there was a difference in closure patterns preoperatively and postoperatively in patients undergoing primary palatoplasty. These techniques could also be used prior to and after pharyngeal flap procedures to determine whether or not the pattern of velopharyngeal closure changes.

It would certainly be important to know why IVVP appears not to make a difference in the results in spite of its theoretical benefit. Certainly, other uncontrolled factors could obscure the one variable of IVVP. Accuracy of judgment of lateral port size, differences in wound healing between patients, height of elevation of the flap, flap length, and so-called "inferior migration" of the flap as well as technical details could all affect outcome.

The incidence of moderate to severe hyponasality following pharyngeal flap placement (7.7% in the study group and 7.7% in the NC control group and 12% in the AZ control group) is distressing. In addition, 22% of the patients in the study group and 11.7% of the patients in the control groups had mild to moderate hyponasality. Van Demark and Hardin (1985) reported mouth breathing in 37.2% of patients undergoing pharyngeal flap surgery, and Smith et al (1985) reported an incidence of 35% of substantial nasal obstruction in patients with pharyngeal flap.

If IVVP is simply added to the pharyngeal flap operation and the dimensions of the lateral ports are estimated in the usual manner, the theoretical benefit of the added procedure may be lost because velopharyngeal competence was already being achieved in the great majority of patients, but with the sequelae of nasal obstruction. Perhaps the theoretical benefit to be sought is the creation of larger lateral ports with a much lower incidence of nasal obstruction while providing more effective dynamic closure of the lateral ports as a consequence of IVVP. The authors consider the possibility worthy of further research.

SUMMARY

Ninety-one patients undergoing pharyngeal flap operation with IVVP were retrospectively compared with 39 patients undergoing the same procedure without IVVP. Over 92% of both groups achieved adequacy by objective measures. An 8 to 16% incidence of moderate to severe postoperative hyponasality suggests a need for increased port size in the performance of the operation.

REFERENCES

BLAKELY R. (1964). The complementary use of speech prostheses and pharyngeal flaps in palatal insufficiency. Cleft Palate J 1:194–198.

BROWN AS, COHEN MA, RANDALL, P. (1983). Levator muscle reconstruction: does it make a difference? Plastic Reconstr Surg 72:1–6.

DREYER TM, TRIER WC (1984). A comparison of palatoplasty techniques. Cleft Palate J 21:251–253.

FARA M, DVORAK J. (1970). Abnormal anatomy of the muscles of palatopharyngeal closure in cleft palates. Plastic Reconstr Surg 46:448–497.

HONJO I, HARADA H, KUMAJAWA T. (1970). Role of the levator veli palatini muscle in movement of the lateral pharyngeal wall. Arch Otol Rhinol Laryngol 212:93–98.

HONJO I, OKAZAKI N, NOZOE T. (1979). Role of the tensor veli palatini muscle in movement of the soft palate. Acta Otolaryngol 88:137–141.

HONJO I, HISATOSHI H, NOBUHIRO U. (1980). Significance of levator muscle sling formation in cleft palate surgery: evaluation by electrical stimulation. Plastic Reconstr Surg 65(4):443–446.

KELLEY AB. (1910). Congenital insufficiency of the palate. Laryngol Rhinol Otol 25:281–300, 342–358.

KRIENS OB. (1969). An anatomical approach to veloplasty. Plastic Reconstr Surg 43:29–41.

MARSH JL, GRAMES LM, HOLTMAN B. Intravelar veloplasty: a prospective study (preliminary report). Presented at the Annual Meeting of the American Cleft Palate Association, New York, May 15, 1986.

OWSLEY JQ, LAWSON LI, MILLER ER, BLACKFIELD, HM. (1966). Experience with the high attached pharyngeal flap. Plastic Reconstr Surg 38:232–242.

SHELTON RL, LINDQUIST AF, CHISUM L, ARNDT WB, YOUNGSTROM KA, STICK SL. (1967). Effect of prosthetic

speech bulb reduction on articulation. Cleft Palate J 5:195–204.

SHELTON RL, LINDQUIST AF, ARNDT WB, ELBERT M, YOUNGSTROM KA. (1971). Effect of speech bulb reduction on movement of the posterior wall of the pharynx and posture of the tongue. Cleft Palate J 8:10–17.

SMITH BE, SKEF Z, COHEN M, DORF DS. (1985). Aerodynamic assessment of the results of pharyngeal flap surgery: a preliminary investigation. Plastic Reconstr Surg 76:402–408.

TRIER WC. (1983). Velopharyngeal incompetency in the absence of overt cleft palate: anatomic and surgical considerations. Cleft Palate J 20(3):209–217.

TRIER WC. (1985). The pharyngeal flap operation. Clin Plast Surg 12:697–710.

VAN DEMARK DR, HARDIN MA. (1985). Longitudinal evaluation of articulation and velopharyngeal competence of patients with pharyngeal flaps. Cleft Palate J 22:163–172.

WARREN DW. (1964). Velopharyngeal orifice size and upper pharyngeal pressure-flow patterns in normal speech. Plastic Reconstr Surg 33:148–162.