

A Preliminary Study of Passavant's Pad

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In 1863 Gustav Passavant first reported his observation of a 'cross-roll' formed on the posterior wall of the pharyngeal cavity (8). Since that time confirmation of the existence of this phenomenon, commonly called Passavant's pad, has been made with some frequency and relatively definitive information has been acquired concerning its location and appearance.

Knowledge of the functional significance of the pad, however, is limited and involves a controversy that appears to center around the following question: Is the pad to be considered a phenomenon which occurs in a random and unorganized fashion in relation to other velopharyngeal activity, or is it to be viewed as occurring in an orderly manner, specifically a manner which may be potentially compensatory in nature?

Blair and Brown (1), Carpenter (3), Cooper (5), Hagerty and Hoffmeister (6), Shelton, Brooks, and Youngstrom (7), and Townshend (8) all offer evidence that in some individuals the pad can or actually does function to aid in effecting velopharyngeal closure. In contrast, Calnan (2) and Veau and Borel-Maissony (2) state, either directly or indirectly, that the pad has little potential for compensatory activity.

The strongest and most definitive contribution to this question of compensation has come from the work of Calnan (2). In opposition to Passavant, Calnan maintained that the pad could not be part of the *normal* velopharyngeal mechanism, arguing that the phenomenon is inconsistent, uneconomical, too low, too slow, and prone to fatigue. These objections to the pad's role within the normal mechanism were applied, also, to possible compensatory activity, with Calnan concluding that only rarely does the pad function adequately for purposes of compensation.

The present report was taken from a larger study (4), designed as a descriptive investigation of the pad and its performance within the total complex of the velopharyngeal mechanism. The contention which extended the focus to the entire system was that isolation of the pad from its functional environment might deny the basic structure of the velo-

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pharyngeal mechanism and ignore important anatomic and physiologic interactions.

The primary experimental question was the following: Considering the relative relationship of velopharyngeal structures, does the pad appear to be functioning as part of a compensatory mechanism? Secondly, two other questions were investigated: a) Are there identifiable patterns of performance within the mechanism relative to particular types of tasks? If so, what are they? b) Do certain performance variables selected for investigation have any influence on the behavior of Passavant's pad? If so, which are they and in what manner are they seen to alter pad function?

Procedure

SUBJECTS. Six subjects, three males and three females, ranging in age from eight to eighteen years, and all having surgically repaired clefts, were selected for study. Each of the subjects was seen to demonstrate a pad on inspection of lateral still head x-ray films and fluoroscopic views of the head.

TASKS. Cinefluorographic films were obtained which included both a continuous speech sample and isolated speech and nonspeech tasks. The continuous sample consisted of the subject giving his name, age, and home town; counting from one to ten; and reading (or repeating after the experimenter) three sentences: one which was constructed with a predominance of plosive consonants, another with fricatives, and the third with nasals.

The isolated speech tasks were primarily designed to investigate four variables: effort, duration, rate, and fatigue. During the effort task the phonemes /s/, /z/, /u/, and /æ/ were produced once with a normal effort, then with twice the normal effort, and again with one-half the normal effort.

In the duration task each of these same phonemes was produced in as short a production as possible while maintaining intelligibility, and then repeated in a prolonged production.

For the rate task the subjects produced both the syllable /sΛ/ and the syllable /zΛ/ a number of times in rapid succession and then again at a rate approximately one-half that of the initial performance.

Each subject repeated the procedures for these isolated speech tasks of effort, duration, and rate to give some indication of the consistency of the mechanism.

During the final segment of filming the subjects continuously read or repeated the original three sentences over an extended period of time so that observations of the possible effects of fatigue could be made. Filming was limited to readings of the plosive sentence and was carried out at the following time intervals: the initial production, after fifteen seconds, after one minute, after three minutes, and, with four of the subjects, after five minutes of continuous reading.

1. Pad
 - a. configuration
 - b. level of projection (relative to the tubercle of the atlas)
 - c. amount of projection (proportion of the pharyngeal depth)
2. Velum
 - a. angle of movement (relative to the palatal plane)
 - b. velar height (relative to the level of the hard palate)
 - c. amount of movement (proportion of the pharyngeal depth)
3. Velopharyngeal opening
 - a. amount of opening
 - b. portion of velum contacting or approximating contact with the pad
4. Generalized posterior pharyngeal wall movement
 - a. amount of movement
 - b. location of movement
5. Relative timing of the mechanism
6. Consistency of the mechanism
7. Tongue movement (limited to descriptions of activity that appeared other than normal)

FIGURE 1. Parameters considered in evaluating cinefluorographic films.

Two isolated nonspeech tasks were also included for comparative purposes. One involved blowing under instructions similar to those given in the effort task for speech. The subjects were required to blow into an oral manometer at the three effort levels for each of three conditions: blowing without bleed, nostrils open; blowing with bleed, nostrils open; and blowing with bleed, nostrils occluded. The other nonspeech task was a swallow sequence in which a barium solution was drawn into the mouth through a straw, held momentarily, and then swallowed.

OBSERVATIONS. These cinefluorographic films were viewed repeatedly at the normal projection speed and descriptive evaluations were made of the velopharyngeal mechanism under the various experimental conditions. The evaluations, both qualitative and grossly quantitative, were structured according to the outline of parameters deemed important for describing the functioning of the pad within the mechanism (shown above in figure 1).

In the analysis of each film the continuous speech sample was viewed first to provide a general description of the mechanism. Subsequent observations of other tasks were made as relative variations from this initial description.

Results and Discussion

To provide an estimate of reliability two other experienced observers evaluated two of the six films according to the procedure for analysis just described. Although somewhat different descriptive terminology was used by each of the observers and the experimenter, reliability of evaluation was judged acceptable for purposes of this study.

In essence, the observations showed that, although the mechanism's basic composition and component relationships differed somewhat between individuals, the patterns of performance under the various task conditions were similar for all subjects.

COMPOSITION OF THE MECHANISM. Generalized observations of the pad indicated that configuration appeared in three basic types: semicircular, triangular, and shelf-like (Figure 2). The level of pad projection was in most cases moderately above the tubercle of the atlas but the amount of projection, as estimated visually, varied between individuals, ranging from one-fifth to one-third of the pharyngeal depth.

The angle of velar movement was seen to be approximately 45 degrees, relative to the palatal plane, for all subjects, while velar height was at the level of the hard palate. The extent of velar movement posteriorly, however, varied between individuals, ranging from one-half to four-fifths of the pharyngeal depth.

The amount of velopharyngeal opening also varied between individuals and ranged from no opening to a very small opening. Variation was again seen in which portion of the velum contacted or approximated contact with the pad. This was seen to range from the middle one-third to the posterior one-third of the velum.

Generalized posterior pharyngeal wall movement varied both within and between individuals.

DYNAMICS OF THE MECHANISM. Relative timing of the components seemed appropriate since the pad and the velum reached the phonatory position simultaneously even though, as the two began their movements,

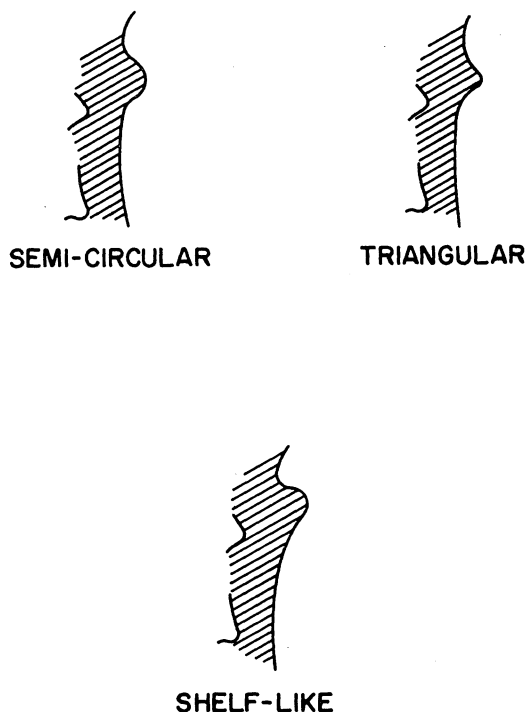


FIGURE 2. Configurations of Passavant's pad observed in the study.

the pad was seen to lag slightly behind the palate. In addition, consistency of the mechanism was quite high within the individual. Tongue movement seemed essentially normal.

PATTERNS OF PERFORMANCE. No differences were noted between the plosive and the fricative sentences in the continuous speech task in terms of the parameters selected for observation. The velum and the pad assumed a phonatory position which was maintained throughout unless interrupted by phrasing. In general, the nasal sentence showed less velar movement and pad projection with a resultant increase in size of velopharyngeal opening.

In the isolated tasks no consistent differences were observed either among the three effort levels for speech or blowing or between any of the conditions for the rate or duration tasks. In addition, no changes were noted in the mechanism under the fatiguing condition.

Generally, when /s/, /z/, /u/, and /æ/ were reproduced in series (in the effort and duration tasks), greater velar and pad activity was observed for the consonants than for the vowels. Of the two vowels, /æ/ evidenced the least palatal movement and pad projection. This difference may reflect restrictions imposed by the particular tongue position involved or may, because of the phoneme's placement in the series, reflect phrasing effects in which the structures begin a return to the rest position before phonation has ended. During rapid repetition of /sΛ/ and /zΛ/ in the rate task both the velum and the pad remained relatively stable for all productions of the same syllable.

Presented in Figure 3 are line drawings which demonstrate variations in the activity of the velar-pad mechanism during rest, speech, blowing, and swallow. In general, blowing evidenced more velar movement than did the speech tasks and showed an increase in all dimensions of the pad, including pad projection in some cases. Velopharyngeal closure was seen in all subjects during this nonspeech task even when it had not been attained in speech. For those subjects who had achieved closure in speech the vertical extent of velar-pad contact during blowing appeared to increase moderately in comparison to the contact observed in the speech tasks. Generalized movement of the posterior pharyngeal wall was seen to increase moderately during blowing over that observed in speech. For the condition of blowing with bleed, nostrils occluded, the majority of individuals studied exhibited no activity of the velum or posterior pharyngeal wall.

Although the presence of a pad was questionable in some subjects during swallow, when readily observable it appeared larger in all dimensions than it had in connected speech. In addition, velar height was somewhat lower and velopharyngeal contact was made with a more posterior portion of the velum in this swallow sequence than in speech. Closure was achieved by all subjects during this nonspeech task also. Generalized pharyngeal wall movement was increased during swallow, when compared with speech, and occurred in a peristaltic manner.

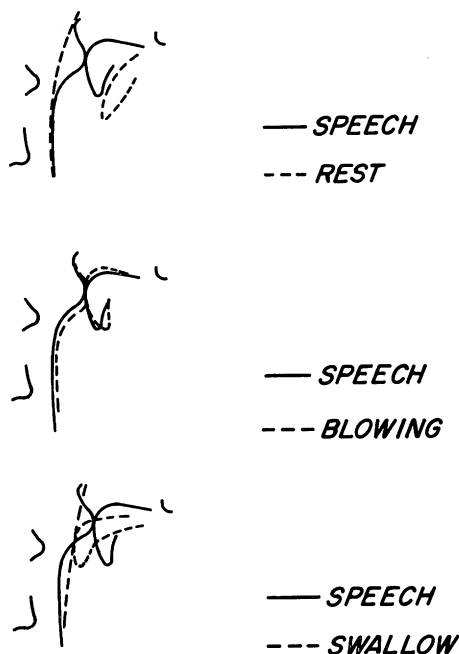


FIGURE 3. Line drawings which demonstrate variations in activity of the velar-pad mechanism during rest, speech, blowing, and swallow.

DISCUSSION. As is apparent from the observations just reported, the composition of the mechanism varied from individual to individual—the basic pad configuration differed, the pad contributed relatively more to closure in some subjects than in others, and the portion of velar contact or approximation with the pad varied between individuals. The end-products or combined effects of the various components were, however, quite similar in that all subjects showed a mechanism either achieving or nearly achieving closure and operating with similar timing and consistency. In addition, there was a similarity in patterns of mechanism performance as evidenced by the parallel trends observed across subjects for the experimental tasks. In general, it appeared that the velar-pad mechanism functions in much the same manner as does the normal velopharyngeal mechanism with the exception of the pad's contribution to closure. In a very basic sense, the pad appeared as just a simple addition to the closure mechanism, leaving the fundamental process undisturbed and acting simultaneously with and complementary to the velum.

Although this was the common picture, certain exceptions to the generalized patterns of performance were observed and should be acknowledged. One was in contrast to the performance of the normal mechanism; the others were individual variations from the typical patterns of pad performance.

The first exception, the only gross difference from the activity of the normal mechanism, was the almost complete lack of structural movement observed during the blowing task with nostrils occluded. This was seen in the majority of the pad subjects studied. To provide additional information in this area the performance of the experimental subjects under the three conditions for blowing was compared with the performance of three other non-pad groups (3 normals, 5 clefts with competent mechanism, and 5 clefts with incompetent mechanism) during the same tasks.

In general, the cleft palate subjects with competent mechanisms behaved in a manner similar to the subjects with pads (no activity with nostrils occluded), while the cleft palate subjects with incompetent mechanisms and the normal subjects showed velopharyngeal movements throughout the blowing series. It is interesting to note that for the majority of individuals who evidenced the phenomenon of no movement with nostrils occluded, brief flickers of activity were seen as this blowing task was begun, following which the structures returned to a rest position for the remainder of the task.

In brief, it might be hypothesized that this difference in performance, activity/no activity, is the result of sensitivity to feedback within the mechanism. An individual with an altered (that is, surgically repaired) velopharyngeal mechanism undergoes a period of relearning with the new structural approximations which could lead to an augmented response to feedback. If the repair has been relatively successful, the individual may reach a level in relearning where subtle discriminations are important and where employment of differential responses, such as that seen in the blowing task, is profitable. If the repair has been unsuccessful, the individual may receive only the gross impression that any attempt at closure is less than successful. Consequently, he is provided with experiences which require only one form of response, his maximal effort, and which as such give little encouragement for the learning of subtle discriminations.

The subjects with pads were seen to have these competent or near competent mechanisms and therefore may be demonstrating this extreme sensitivity to feedback. It may well be that just the presence of a pad is substantial evidence of a hypersensitivity in these individuals. In contrast, individuals with normal velopharyngeal mechanisms might be considered similar to those with incompetent cleft mechanisms in that no experiences have been provided requiring subtle discriminations. As the incompetent clefts have never met with success, the normals have always been successful and thus have never found it profitable to make differential responses.

Three exceptions to the typical patterns of velar-pad performance were noted. One was seen as a unique velar-pad relationship during isolated productions in series (phonemes and syllables). In two subjects the velum and pad were observed to assume their usual position for phonation and then, while the velum maintained its posture throughout the series, the

pad was seen to fluctuate in and out from the posterior wall in appropriate accord with each phoneme or syllable production. An explanation for this phenomenon wasn't apparent from the information acquired in this study; however, it might be viewed as a demonstration of highly specific mechanisms.

Another variation in the patterns of performance was observed in the blowing tasks. At these times the velum rose above the pad, directly contacting the posterior pharyngeal wall and seemingly resting on the pad (Figure 4). Again, this was seen in two individuals, one of whom had also shown the independent movement of the pad against a stable velum as just described. These subjects were also the only ones seen to typically make velar-pad contact with the posterior third of the velum. If, then, they follow the common trend of greater activity during the blowing tasks and consequently an exaggeration of velar movement, this increase would necessarily bring the velum above the level of the pad, permitting it to continue back to the posterior pharyngeal wall.

The third exception was found in these same two subjects. Like the normal velopharyngeal mechanism, but unlike the majority of the velar-pad mechanisms observed in this sample, structural activity was seen to continue during the blowing task with nostrils occluded. Abnormal tongue movements were also in evidence in these cases. The tongue was humped, filling the entire oral cavity, and appeared to assist the velum in making the necessary movement for closure. If it could be hypothesized that lack



CONNECTED SPEECH



BLOWING WITHOUT BLEED

FIGURE 4. Exceptional pattern of movement observed in two subjects during the blowing task.

of velar-pad activity in the other subjects was a function of exceptional sensitivity to feedback, and if it could also be hypothesized that this was dependent on a relatively effective closure, the unique pattern in these subjects of direct contact of the velum with the posterior wall during blowing may have introduced a less effective closure pattern (as suggested by the assist from the tongue) and consequently altered the feedback. This explanation, however, is based on a number of assumptions and is obviously open to question.

Comments

Despite the exceptions noted above, certain general observations from this study would appear to question any unrestricted application of Calnan's statements to the population with pads.

First, Calnan objected to the pad as a compensatory phenomenon because of its inconsistency. Although the basic composition of the mechanism differed somewhat for each subject studied, pad activity was found to be consistent both within and between individuals. Admittedly, the internal consistency was greater, but if pad activity is considered as compensatory behavior, consistency within individuals, as compared to between, might be considered the more important factor.

Secondly, he considered the pad uneconomical in terms of the need for anterior-posterior narrowing of the pharynx. Obviously, this statement was made in reference to the normal mechanism where the velum alone provides a sufficient decrease in the anteroposterior pharyngeal distance. An individual with velar incompetence, however, might profit from the type of narrowing provided by the pad and could, therefore, employ it economically as the subjects in this study appeared to do.

Thirdly, Calnan thought the pad too low on the posterior wall for effective contact with the velum. Four of the six experimental subjects, however, were observed to have pads moderately above the level of the tubercle and, therefore, approximately at the point which Calnan cited for normal velopharyngeal closure. In addition, the majority of the subjects did not demonstrate contact of the pad and the most posterior-inferior aspect of the velum, which might be expected if the pad were too low. In any event, it is seemingly more important to consider the effectiveness of contact, rather than the level at which it occurs.

Calnan also thought that pad activity was too slow for purposes of compensation. It is difficult to evaluate rate of movement from the observations made in this study; however, all subjects appeared to have coordinated velar-pad movements under all circumstances. Furthermore, extreme rapidity of movement does not seem to be required of the velar-pad mechanism since it assumes and maintains a relatively stable phonatory position during connected speech, with the exception of the necessary adjustments for nasal consonants.

Lastly, Calnan objected because he considered the pad fatiguable.

In the present study no change was noted in the function of the mechanism even after five minutes of continuous speaking. It is conceivable that differences could occur under grossly extended periods of phonation; however, such excessive conditions would be expected to produce effects in all components of the mechanism and not just the pad. There is always the possibility, too, that a general physical fatigue, rather than one induced by excessive speaking, could alter pad performance as it would other muscle behavior.

Calnan's objections were directed principally to the concept of the pad as part of the normal velopharyngeal mechanism; however, his arguments were extended to include possible compensatory phenomena and the conclusion drawn that compensation was improbable in most individuals. Even though the present study used only a small number of subjects, it seems unlikely that the circumstances of subject selection and the criteria used would produce only these rare cases. If a compensatory mechanism is considered as one in which adequate structural relationships are possible and in which behavior is seen to be effective, appropriate, and consistent, the mechanisms of the subjects studied would appear to fit the definition without exception. However, acknowledging that there are individuals in whom the pad appears as Calnan described it, just the mere presence of the phenomenon, regardless of its effectiveness, would suggest that compensation is taking place, at least to some extent. Compensatory learning theoretically requires some degree of positive feedback to establish behavior responses. If an individual has insufficient muscular tissue, inappropriate placement of muscle fibers, or is unable for whatever reason to activate the mechanism to a significant degree, it is unlikely that reinforcement will be received and, therefore, unlikely that the behavior will persist. If, however, the pad is observable in an individual over a period of time an explanation for its presence is difficult unless one attributes it to compensatory learning. Some form of positive feedback must be available to maintain the behavior. It must be remembered that the issue at hand is one of compensation, not *degree* of compensation. The controversy concerning the pad's functional significance has quite possibly been both confused and confounded by the failure to make clear just such a distinction.

The evaluations made in the present study, in addition to contributing information to the question of compensation, suggest that the pad is most meaningfully studied as a part of the mechanism within which it is seen to function. Effectiveness of the mechanism is an obvious result of velum and pad interaction. It would appear to be of little or no value to treat the pad in isolation, to know its dimensions and its patterns of performance, unless one considered how these related to similar aspects of the velum within the dimensions of a particular pharyngeal cavity.

Before making any final statements, certain limitations inherent in this study should be acknowledged. All evaluations made from cine-

fluorographic films require qualification in that observations are restricted to structures as seen in the midsagittal plane, whereas important activity may well occur outside of this viewing field. In addition, the usual observational limitations in such films, such as rapidity of movements and diffusion of soft tissue outlines, were present to some degree in this study and made certain aspects of the judging task difficult. Furthermore, valid estimates of the individual contributions of the various mechanism components are difficult, if not impossible, when the individual under study achieves closure. Isolated evaluations of pad configuration, amount of pad projection, and amount of velar movement are distorted by the velar-pad contact. Lastly, although the segment of the study designed to investigate the influence of certain variables on the mechanism's performance showed no consistent trends, it is possible that such effects would become apparent under more exacting conditions. Providing the subjects with more specific instructions, increasing the pre-filming practice time, or employing high speed photography might significantly alter the outcome.

Considering these restrictions to interpretation, particularly in light of the preliminary nature of this investigation and the small number of subjects employed, it is apparent that any conclusions drawn from this study are at best tentative. Although the observations made here have consistently supported the notion that pad activity is compensatory in nature, the controversy regarding the pad's functional significance is far from being resolved. The information available from this study and other sources is too limited in breadth and depth to warrant considering one side of the issue more heavily weighted than the other. It may even be that the existing division into positive and negative evidence is a function of differing definitions of compensation and is not the result of conflicting observations. Any definitive contributions to this question of compensatory potential must await both more intensive and more extensive research efforts developed from well formulated definitions and undertaken with clearly specified criteria.

Summary

Six individuals who had surgically repaired cleft palates and who exhibited Passavant's pad were selected for observation. Cinefluorographic films, taken while the subjects performed a variety of speech and non-speech tasks, were evaluated in a qualitative and a grossly quantitative manner to provide information regarding the mechanism involving the velum and the pad. The results of the investigation indicated the following conclusions. a) Although the basic component relationships within the mechanism varied from subject to subject, the patterns of activity seen in the various tasks (speech, blowing, swallow) were highly parallel between individuals. These patterns were similar to the performance of the normal velopharyngeal mechanism. b) No consistent variations in

patterns of velar-pad function were noted under the particular task conditions selected for investigation (effort, rate, duration, fatigue). c) Pad activity, as viewed within the mechanism, appeared to be compensatory in nature in terms of the reduction in the velopharyngeal opening and in terms of the appropriate and consistent manner in which this reduction took place.

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References

1. BLAIR, V. P., and BROWN, J. B., Dieffenbach-Warren operation for closure of congenitally cleft palate. *Surg. Gyn. Obst.*, 59, 309-320, 1934.
2. CALNAN, J., Modern views on Passavant's ridge. *Brit. J. plastic Surg.*, 10, 89-113, 1957.
3. CARPENTER, C. R., A serial radiographic study of the functional changes of the soft palate and nasopharynx during phonation of certain vowels and consonants in operated cleft palate patients. M.S. thesis, Northwestern University, 1953.
4. CARPENTER, MARY A., A preliminary study of Passavant's pad within the velopharyngeal mechanism. M.A. thesis, University of Iowa, 1966.
5. COOPER, H. K., Cinefluorography with image intensification as an aid in treatment planning for some cleft lip and/or cleft palate cases. *Amer. J. Orthod.*, 42, 815-826, 1956.
6. HAGERTY, R. F., and HOFFMEISTER, F. S., Velopharyngeal closure: An index of speech. *Plastic reconstr. Surg.*, 13, 290-298, 1954.
7. SHELTON, R. L., JR., BROOKS, ALTA R., and YOUNGSTROM, K. A., Articulation and patterns of palatopharyngeal closure. *J. speech hearing Dis.*, 29, 290-408, 1964.
8. TOWNSHEND, R. H., The formation of Passavant's bar. *J. Laryng. Otolaryng.*, 55, 154-165, 1940.