THE ORAL MANOMETER AS A DIAGNOSTIC TOOL IN CLINICAL SPEECH PATHOLOGY

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The purpose of this paper is to review the status of the oral manometer as a diagnostic tool in clinical speech pathology. The bases for the review are research findings as well as extensive personal clinical experience with the instrument during the last eight years. The motivation for the review comes from the personal conviction that the oral manometer is a useful clinical tool when it is used properly and when the obtained results are interpreted in ways which are consistent with our current knowledge of it.

A variety of manometric and spirometric techniques have been reported in the literature as methods of assessing velopharyngeal efficiency in nonspeech tasks (Kantner, 1947; Buncke, 1959; Spriestersbach and Powers, 1959; Chase, 1960; Hanson, 1964). The principle involved in the several techniques is essentially the same: to provide a method for quantifying the amount of oral air pressure which is applied to a mouthpiece of some kind. This measurement can be the number of inches or millimeters which a column of water or mercury is forced up a glass tube, or it can be the number of ounces of pressure per square inch in a pressure chamber. This discussion will be primarily about the use of the Hunter oral manometer[1] which has been commercially available for several years and which has proved to be particularly practical in clinical use for reasons of size, portability, and ease of handling. Many of the considerations presented here may also be applicable to other kinds of manometers.

The method commonly employed to obtain a manometer ratio is not new. It was described first by Kantner (1947) as a procedure used with a wet spirometer to assess palatal efficiency. In general, the method is as follows. The individual is required to blow through

[1]Hunter Manufacturing Company, Iowa City, Iowa.

the mouthpiece into the pressure chamber. Two kinds of readings are obtained: one with the nostrils open and one with the nostrils occluded. The ratio is formed between the two readings by dividing the reading obtained with nostrils open by the reading obtained with nostrils occluded. The resulting ratio will be a decimal less than 1.00 if the reading for nostrils open is smaller than for nostrils occluded; it will be 1.00 if the two readings are the same; and it will be larger than 1.00 if the reading for nostrils open is larger than for nostrils occluded.

Two kinds of efforts may be used to obtain pressure readings: indications of positive pressure, obtained when the individual is asked to blow into the mouthpiece; and indications of negative pressure, obtained when the individual is asked to maintain a prolonged *intake* of air from the mouthpiece into the lungs, an activity which is essentially the opposite of blowing, and over a relatively extended period of time.

Following is a series of 12 statements summarizing the information which we currently have about the manometer.

Manometer ratios can be interpreted as an indication of velopharyngeal competence for a nonspeech activity. The manometer ratio permits comparison of readings of air pressure which the individual can achieve in his best attempt to prevent nasal escape of oral air pressure by velopharyngeal function (the nostrils-open trial) with that which he can achieve with prevention of nasal escape of oral air pressure by mechanically blocking the nostrils (the nostrils-occluded trial). If the reading obtained with the nostrils occluded is the same as that with the nostrils open, the inference is that the individual can prevent nasal escape of oral air pressure as efficiently by velopharyngeal function as it can be prevented by mechanically blocking the nostrils. If, on the other hand, the pressure reading obtained with the nostrils occluded is higher than that obtained with the nostrils open, the inference is that he cannot successfully prevent the nasal escape of oral air pressure by velopharyngeal function and that there is velopharyngeal incompetence during that task.

Manometer readings are not to be considered measures of intraoral breath pressure. Some previous investigators, such as Goddard (1959), have implied that manometer ratios supply information about adequacy of intraoral pressure. Recent research, particularly that involving the use of a pressure-sensing tube and a pressure transducer, indicates that the manometer readings are far too gross a measure to be considered in such a light. The clearest statement that we can make presently about the nature of the reading is that it represents the number of ounces per square inch of pressure that the individual can blow into the pressure chamber of the device. The ratio indicates the relationship between the readings obtained under the two conditions as it pertains to the relative efficiency of the velopharyngeal mechanism. To the extent that we can make inferences about efficiency of the velopharyngeal mechanism during speech from that information, then statements regarding the adequacy of intraoral pressure which may be potentially useful for speech production can be made. It is probably preferable to consider the manometer ratio as an indication of velopharyngeal competence for that task, and perhaps for speech, and to avoid making statements about the adequacy of intraoral breath pressure for speech.

Absolute manometer readings are not useful at the present. There is not enough information about what are considered "adequate" manometer readings to interpret a single reading obtained under either the nostrils open or nostrils occluded condition. Clinical experience suggests strongly that there are substantial differences even within the normal population in ability to perform the task under essentially standard conditions. Those between-subject differences in absolute readings are not relevant in computing ratios, however, since the comparison to be made is between two trials made by the same subject.

Ratios computed from readings obtained with a constant leak of pressure in the system are more useful than those computed from readings obtained with a closed system. Manometer ratios are valuable in the diagnostic sense to the extent that they reflect velopharyngeal competence during the blowing task. However, it is possible to impound pressure in the mouth by establishing contact between the tongue and palate, such as we do when we puff out our cheeks. It can be demonstrated that the velopharyngeal port is open during such tongue-palate contact since we can puff out the cheeks and breathe through the nose at the same time. If one can breathe through the nose, clearly the velopharyngeal port is open.

It follows that in order to assess velopharyngeal function during blowing, the technique which is employed must be designed in such a way that tongue-palate contact is prevented (Chase, 1960; Barnes and Morris, in preparation). When an opening to atmosphere is introduced into the pressure chamber of the manometer, a leak of pressure in the chamber occurs and the individual is forced to supply more air pressure to the mouthpiece to maintain the obtained manometer reading. Since he cannot supply more air pressure from the lungs while maintaining tongue-palate contact, he is forced to rely on closure of the velopharyngeal port to prevent nasal emission of oral air pressure during the blowing activity.

We have little information about the optimal size of the bleed or leak to be employed. Within limits, the larger the aperture, the less easily the individual can maintain buccal (or cheek) pressure by tongue-palate contact. On the other hand, if the orifice is too large, the individual will be unable to compensate for the loss of pressure escaping through the bleed mechanism, and the manometer reading will not be stable but will consistently decrease in value. An orifice size of $\frac{1}{16}$ inch seems adequate for the Hunter manometer.

Use of the bleed mechanism is especially important in computing ratios with negative pressures and, in that connection, the difference between sucking and a prolonged intake of air into the lungs should be considered (Barnes and Morris, in preparation). Buccal pressure can be impounded with a closed pressure system in somewhat the same way that we drink liquid through a straw. (Liquid is first sucked up into the mouth by establishing tongue-palate contact, then the liquid is swallowed.) The act of sucking, then, into a closed pressure system does not involve an attempt at closure of the velopharyngeal port and ratios based on it do not reflect velopharyngeal competence. If a planned leak of pressure is introduced into the system, the individual is no longer able to suck by using tongue-palate contact and, as in blowing, is required to attempt velopharyngeal closure in order to maintain the manometer reading.

Use of a bleed mechanism is so important in obtaining ratios based on negative pressure ratios that, if bleed is not used, the obtained values can be very misleading, even indicating competence when the individual has a velopharyngeal opening.

The wet spirometer ratio, referred to earlier in this paper, has been used in several investigations as an index of velopharyngeal competence (Spriestersbach and Powers, 1959; Morris, Spriestersbach, and Darley, 1961; Spriestersbach, Moll, and Morris, 1961; Pitzner and Morris, 1966). In that technique, there is a slow leak of air between the two cannisters of the spirometer, resulting in effect in a bleed device which is comparable to that described for the manometer. For that reason, the wet spirometer is preferred over the oral manometer without a bleed device. The chief disadvantage to the spirometer is its relatively large size and cumbersomeness.

Manometer ratios must be viewed dichotomously as they relate to velopharyngeal incompetence. It is reasonably safe to assume that a manometer ratio of 1.00 indicates velopharyngeal competence for the blowing task. It is also safe to assume that a ratio of a value less than 1.00 indicates velopharyngeal incompetence for that task. The difficulty is that we have no information on which to base interpretations of the *relative* significance of ratios less than 1.00; that is, we are not able to say that a ratio of 0.25 represents or indicates poorer velopharyngeal closure, or a larger velopharyngeal opening, than a ratio of 0.50. In the same way, we are not able to specify whether complete velopharyngeal closure, or no velopharyngeal opening, is associated only with pressure ratios of 1.00 or whether ratios of 0.99, or 0.95, or 0.90, may also indicate competence. Presently, the best we can do is to consider manometer ratios in a dichotomous way, that is, ratios of 1.00 indicate competence and ratios less than 1.00 indicate incompetence or at least a velopharyngeal opening of some size.

Occasionally an individual will obtain a higher reading during the nostrils-open trial than during the nostrils-occluded trial, resulting in a ratio greater than 1.00. Usually, the difference in the two readings is related to difficulty which the individual has in blowing with nostrils occluded, and the inference can be made that the "true" ratio is 1.00. Many times, repeated testing results in a higher reading for the nostrils-occluded trial and hence a ratio which more closely approximates 1.00.

Although there is no clear preference between positive and negative readings, clinically, the blowing task seems easier for most individuals. It is necessary to point out that sucking is a misnomer and that the desired performance actually consists of drawing air into the lungs through the mouth. This act is relatively difficult to describe adequately, particularly for small children, and usually a demonstration is necessary. For that reason, it seems preferable to ask the individual to blow, if only in terms of ease of administration.

Precautions should be taken to encourage subjects to blow with similar amounts of effort during the nostrils-open and nostrils occluded trials. Current knowledge about the relationships between pressure and volume for the human respiratory system indicates that differences in lung volume can result in differences in pressures (Hardy, 1965). Clinically, this means that a higher manometer reading for the nostrils-occluded trial than for the nostrils-open trial could result from having taken a deeper breath (greater lung volume) for the former trial than for the latter trial, and not from having blocked the anterior port of the nasal cavity. Ideally, then, it is desirable that the individual demonstrate comparable amounts of effort (lung volume) for the two trials and that he always be instructed to "take a deep breath" before doing either trial. Such instruction is adequate for most purposes, for differences in lung volume do not appear to be significant in computing ratios for the majority of clinical and research purposes.

The size of the manometer ratio may be affected by the presence of ear disease. When an individual with Eustachian tube dysfunction is asked to blow into the manometer with nostrils occluded, he may experience pain or a "popping" sensation when the tube is inflated. For that reason, he may be reluctant to blow into the manometer with the same effort on the nostrils-occluded trial as on the nostrils-open trial. If the individual is capable of adequate velopharyngeal function, the value for nostrils open will be greater than for nostrils occluded and the ratio greater than 1.00. That ratio can be interpreted to indicate velopharyngeal competence for the task, which is the finding that would have been made if the individual had not had the Eustachian tube dysfunction.

On the other hand, the individual who is not capable of adequate velopharyngeal function may obtain ratios which indicate competence because the nostrils-occluded reading is spuriously low, thereby bringing the ratio closer to a value of 1.00. For example, assume that the true ratio for such an individual is $6/10$ or 0.60. He is reluctant, however, to make his best effort on the nostrils-occluded trial and obtains a reading of 6 instead of the "true" 10. The resulting ratio of 1.00 is misleading and supports a misdiagnosis of velopharyngeal competence.

It is difficult to assess the importance in everyday clinical practice of this factor and we have no research data relevant to the question. Occasionally, we can observe the individual, particularly a child, wince as the tubes are inflated. Many children will comment about it. At the very least, the clinician needs to know about current or past middle ear disease for the individual being examined. If adequate medical information is not available, he can inquire whether there have been recent ear complaints. If there have been such complaints or middle ear disease, manometer readings with nostrils occluded should be obtained, but interpretation of ratios should be made with special care.

Reliability of manometer ratios appears high enough for most purposes. There is sufficient evidence to indicate that two observers can agree on a computed ratio for an individual about

80% of the time and that, if the criterion is less stringent than exact agreement, the percentage of agreement is even higher (Barnes and Morris, in preparation). In general, reliability is relatively high when each reading is based on several attempts, when a bleed device is used, and when the criterion of point of needle stabilization, rather than peaked reading, is employed. There is no evidence, however, regarding an individual's variability in manometer ratios and that needs to be investigated. For the majority of clinical and research purposes, reliability of the technique seems adequately high.

There are differences in velopharyngeal function for speech and nonspeech activities which are probably important in considering the use of manometer ratios as a diagnostic tool. Regardless of how easy a diagnostic test is to administer, the question of its usefulness ultimately comes down to one of interpretation of results. For the manometer ratio, this involves the inference to be made about speech activities from observations based on nonspeech activities. The objective is to use the manometer ratio, based on blowing activities, to predict the adequacy of velopharyngeal function during speech. If such an inference is made, and manometer ratios have been shown to be useful for that purpose, the inference must be made with care and the basis for the generalization clearly specified.

There is sufficient evidence to indicate that there are differences in velopharyngeal function for speech and nonspeech activities (Moll, 1965). For one thing, nonspeech tasks usually involve the more reflexive activities, such as swallowing, gagging, yawning, blowing, and sucking, and it appears that velopharyngeal function for such reflexive activities is more extensive and more gross than for speech activities. For example, even the individual with a very large velopharyngeal opening in all speech tasks achieves closures of the nasopharyngeal port during swallow. One implication of this observation is the possibility that such nonspeech tasks involve more "all-out" effort in velopharyngeal function than do speech tasks. Another is that velopharyngeal movement in speech takes place so rapidly that, if proper function can be achieved only with maximal extension, there is not time enough to achieve appropriate movement during speech.

If errors are made in predicting from nonspeech to speech activities, they probably would be in the direction of predicting competence when in reality competence is not possible in speech. An individual might achieve velopharyngeal closure during a gross "all-out effort" task such as blowing, yet not be able to effect contact during rapid-fire connected speech.

In summary, manometer ratios are useful in predicting adequacy of velopharyngeal function for speech so long as these limitations are kept in mind and so long as generalizations are made with appropriate caution.

Manometer ratios are most useful in predicting adequacy of velopharyngeal function during speech when used in connection with other diagnostic techniques. The best way to diagnose adequacy of velopharyngeal function during speech is to *assess* velopharyngeal function during speech. That means that the clinical speech pathologist can probably learn the most about velopharyngeal function in speech by conducting careful articulation tests and, in particular, assessing possible change in nasal emission of air pressure in consonant articulation following auditory and visual stimulation of the speech sound which was made in error. Many times, an individual (especially if a small child) appears unable to give his best response to a speech task because of attitudes of defeatism or simply because he has not learned to make a specific response. In that case, manometer ratios and measures of air pressure and air flow rate may be helpful in learning more about velopharyngeal function.

X-ray films, on the other hand, give us information about structural relationships and only indirectly about function. If an x-ray film is taken during the production of an /s/ which is distorted by nasal emission of oral air pressure, we can predict with some certainty that the film will demonstrate velopharyngeal opening of some size. We can't specify the size of the opening from judging the amount of distortion of the /s/, but we can estimate size of opening from inspection or measurement of the film. X-ray films, particularly of the cinefluorographic variety, are helpful in interpreting differences in diagnostic test results when the individual demonstrates marginal or borderline velopharyngeal competence, or when the problem appears to be one of timing.

There are no indications that the manometer is particularly useful in therapy. Research and clinical reports about the oral manometer have involved its use as a diagnostic technique. No reports were found regarding its use in therapy. Certainly manometer *ratios* have no meaning in therapy. If a clinician subscribes to the belief that blowing activities "strengthen" velopharyngeal function or facilitate velopharyngeal function during speech, then the manometer can be used as easily as a feather or a lighted candle. Considerations such as the efficacy of blowing activities in therapy are not relevant to this discussion, however.

SUMMARY

Manometer ratios are useful clinically and in research as a somewhat gross measure of the efficiency of the velopharyngeal mechanism during blowing. With current information, ratios must be viewed as having a dichotomous relationship with velopharyngeal competence: a ratio of 1.00 indicates competence, and a ratio of less than 1.00 indicates incompetence of some unspecified amount. A bleed valve in the pressure system is necessary to prevent the individual from maintaining buccal or cheek pressure with tongue-palate contact. There is evidence of differences in velopharyngeal function between speech and nonspeech activities that may be important in making inferences about velopharyngeal function during speech from observations about velopharyngeal function during blowing. The best we can do currently is to assume that there is a high relationship between the two activities and that, if errors are made, they are in the direction of predicting

competence when in reality the velopharyngeal mechanism is not capable of adequate function during speech. In all such diagnostic work, manometer ratios should be used in collaboration with speech tests and perhaps x-ray films so that the inference to be made about adequacy of velopharyngeal function is based on as many relevant observations as possible.

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