USE OF THE ENDOTRACHEAL CUFF:
SOME DATA PRO AND CON

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Despite almost universal acceptance of the endotracheal cuff and its obvious advantages there is still some opposition to its use. Certain of the objections appear to be based upon conjecture and impressions rather than facts (1). Data on the cuff, save for details of construction, are lacking. A study to obtain data to support or refute arguments for or against the cuff seemed desirable. The following are the commonly voiced objections to the cuff and some overruling or supporting data obtained in this study.

TRAUMA

Undue trauma to the trachea may result from rupture or sustained pressure of the cuff. Reports of complications occurring during endotracheal intubation are plentiful. However, even though these incriminate various aspects of the technique, such as misuse of the laryngoscope, forcing the catheter, and trauma from stilets, those directly ascribed to the use of the cuff are remarkably few. Lennon and Rovenstine (2) reported a fatality which they ascribe to the rupture of an endotracheal cuff. The trauma described was extensive and obviously resulted from a tremendous expansile force. Immediately after the accident, shock developed. Coma, subcutaneous emphysema, and respiratory difficulty developed later. The patient died within 24 hours. Rupture of the trachea, contusions of the bronchi and hemorrhages throughout both lungs were noted at postmortem examination. The pathologic findings mentioned are strikingly similar to those ordinarily ascribed to blast injuries resulting from explosions (3). This

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case report has been repeatedly cited by certain writers and the impression has been created that this is a common and frequent accident. In reality, it is the only report of its kind in the medical literature. Grim and Knight (4) reported a case in which an 8-year-old male developed respiratory obstruction following endotracheal intubation two days postoperatively. He died on the seventh day from tracheal obstruction owing to a firmly adherent mucous plug. In their opinion, the train of events was initiated by trauma caused by the cuff. Even in this case, little evidence existed to indicate that excessive pressure exerted by the cuff may have been the causative factor. Necrosis of the trachea and slough of the mucous membranes has been reported after the use of cuffed catheters following deliberately induced hypo-

tension (5). Presumably, this was due to pressure of the cuff in the face of ischemia resulting from the hypotension. Packs, retractors, and other devices causing pressure, particularly pressure which was sustained over a period of time, have also caused necrosis under similar circumstances (5).

All of this leads to a number of questions. Is the pressure in an inflated cuff of such magnitude in the event of rupture to cause trauma similar to that of a blast? Is the pressure ordinarily exerted by a cuff on the tracheal wall sufficient to cause local ischemia and slough? Data on the lateral pressures that cuffs exert on the tracheal wall, and the correlation of such pressures with intracuff pressures have not been available.

The apparatus used in this study to measure intracuff pressures was arranged as follows: A mercury manometer was connected to a 3-

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**Fig. 1.** Arrangement of manometers used to measure intracuff pressures and pressure exerted by cuffs on the internal surface of the airway.
way stopcock. One limb of the stopcock communicated with the
catheter leading to the cuff; the other to a 50 cc. syringe (fig. 1).
Cuffs of various sizes and styles, composed of latex or Penrose drain
were studied. Observations were first made by inflating the cuffs in a
glass tube of 2.4 cm. internal diameter. This diameter closely ap-
proximates that of the human male trachea. The cuffs studied were
on catheters whose sizes ranged from 30–40 French. Thus, the effects
of varying the distance between the wall of the glass tube and the outer
wall of the catheter could be studied. The volumes of air necessary
to inflate the cuffs to the point of effecting a seal varied from 8 to 12 ml.
The intracuff pressures which developed when these volumes were used
ranged from 90 to 220 mm. of Hg. The pressures in new cuffs were

\[ \text{Figure 2. A typical curve showing the relationship of the intracuff pressures to volume}
\text{of air necessary to inflate a conventional endotracheal cuff. The dip commencing at (A)
\text{signifies the reduction in pressure due to bulging outward of the cuff at its weakest point.}} \]

somewhat higher than those in old cuffs. The highest pressures were
noted in 2 home-made cuffs, 2 by 2.5 centimeters in length composed of
Penrose drain. These were shorter than the commercially available
cuffs. The pressures, using 5 ml. of air in various cuffs, ranged from
100 and 150 mm. of Hg; 10 ml. of air yielded pressures ranging from
150 to 200 mm. of Hg; 15 ml. between 150 and 325 mm. of Hg; 20 ml.
between 250 to 500 mm. of Hg; and 25 ml. between 325 to 625 mm. of
Hg (fig. 2). Pressures in old cuffs were 5 mm. of Hg less than in new
cuffs of the same size, design, and material. The pressures in cuffs
inflated without restriction (not in a tube or in the trachea) increased
as the volume of air increased until a peak was reached (fig. 2). Fur-
ther addition of air caused the cuff to balloon out at its weakest point.
The pressures declined at this point to levels below the peak (fig. 2).

Intracuff pressures were also studied in intubated anesthetized
The pressure volume relationships were identical to those obtained when cuffs were inflated in a rigid glass tube. The graphic picture was the same as in the in vitro studies. After the maximum pressure was attained, represented by a plateau on the graph (fig. 2—A), the curve dipped downward. This downward dipping of the curve coincided with ballooning out of the cuff.

Intracuff pressures were then determined in 25 intubated patients. The volume of air necessary to inflate the cuff to effect a seal when the breathing bag was compressed so that 20 cm. of H₂O pressure was present in the inhaler varied from 2 to 6 ml and averaged between 3 and 4 ml. The volume-pressure relationships in patients were the same as those in dogs and in the glass tubes. As one would expect, the larger the endotracheal catheter employed, the less the space between catheter and the trachea, the less the volume of air necessary to inflate the cuff, and the less the intracuff pressure necessary to effect a seal.

The next questions which arose were: How much of the intracuff pressure is utilized in overcoming the elasticity of the rubber composing the cuff? How much pressure does a cuff exert on the tracheal wall? Contrary to the impression of many, as the following data show, the intracuff pressure is no index of the pressure exerted by the cuff on the tracheal wall. An unrestricted cuff becomes distended until the pressure over its surface equals the atmospheric pressure existing at the moment. When a cuff is inflated in a rigid tube or in a trachea, the pressure, obviously, is greater than atmospheric at the area of contact with the wall of the tube. The pressure at the exposed portions in contact with atmospheric air equals that of the atmosphere. The pressure exerted by a cuff at the point of contact was measured by incorporating a tambour in the wall of a metal tube, 2.4 cm. in diameter (fig. 1). The tambour was connected to a water manometer. The cuff, when inflated, exerted a lateral pressure upon the tambour. Cuffs were inflated sufficiently to grip the wall so that a leakproof system resulted, when the breathing bag was compressed to exert pressures between 10 and 15 mm. of Hg. The resulting lateral pressure varied between 10 and 15 mm. of Hg (fig. 3). The intracuff pressures, which were measured simultaneously, ranged between 20 and 120 mm. of Hg. The lateral pressures were relatively constant. They were all within this range irrespective of the type of cuff, and the material of which the cuff was composed, provided that the pressures in the breathing bag were maintained between 15 and 20 mm. of Hg. The intracuff pressures, on the other hand, were subject to greater and less predictable variations. This is understandable since this pressure depends upon such factors as the elasticity of the rubber, the size of the catheter and distance between the catheter and the interior of the trachea. Most of the intracuff pressure is expended in overcoming the elasticity of the rubber.
composing the cuff. This is an extremely variable factor. The thinner and the less elastic the rubber the less the pressure. As one would expect, the larger the catheter, the smaller the space between the cuff and the tracheal wall, and the less the volume of air necessary to inflate the cuff to obtain a leakproof seal. When small catheters are used, the distance between the catheter and the tracheal wall is increased. Obviously, a larger volume of air is necessary to inflate a cuff on such a catheter. The intracuff pressure necessary to obtain a seal is increased. The pressure exerted by the cuff on the tracheal wall is not (fig. 3). One should note that the lateral pressure required to effect a seal approximates the capillary blood pressure found in most tissues. The possibility of ischemia in instances in which the cuff is inflated for hours at time, particularly if the cuff is over inflated, cannot be discounted.

In dogs, inflating cuffs with volumes of air greater than those necessary to effect a seal and sustaining this excessive pressure for several hours caused the trachea to stretch. The diameter was increased as much as 50 per cent. Stretching occurs because the dog’s trachea is thin walled and the cartilaginous rings are not fused posteriorly. Stretching does not occur to the same extent in man because the trachea is thicker. The rings, however, are incomplete posteriorly.
and are held together by the fibers of the musculus trachealis. Some clinicians contend the muscle fibers relax during deep anesthesia and cause the tracheal diameter to increase so that further inflation of the cuff is necessary to maintain a tight fit. This aspect of the problem was not studied.

The effects of deliberately rupturing cuffs were studied in anesthetized dogs. Old and new cuffs, of a variety of sizes, of latex and Penrose drain were used. Slowly inflating a cuff caused, as one would expect, a gradual rise in pressure. In most instances, as much as 40 ml. of air could be introduced without rupture if the cuff was inflated slowly. The resulting intracuff pressures averaged 1,000 mm. of Hg or more. Unless the cuffs were old and extremely friable, rupture was virtually impossible by gradual inflation using this volume of air. Rupture occurred only after this volume of air was introduced rapidly and then only after several attempts. The dogs were killed at intervals varying from several hours to a week after intubation. No evidence of trauma to the trachea, bronchi or alveoli could be detected grossly in any dog examined immediately after intubation. There were, however, areas of congestion of the tracheal mucosa at the point of contact of the endotracheal cuff in dogs killed several hours after intubation when the cuff remained in contact with the mucosa for an hour or more. This congestion was absent in dogs studied several days after intubation. There was no evidence of trauma to the trachea, bronchi or lungs of dogs in whom the cuffs were ruptured.

These data indicate that the possibility of causing unusual trauma to the respiratory tract by the inadvertent rupture of a cuff is remote and has been grossly exaggerated.

**Overdistention**

*The cuff may be overdistended and occlude the lumen of the catheter.* This is a valid objection. However, this accident is avoidable because it is due to needless over-inflation of the cuff. Bulging outward of a section of the cuff at its weakest point occurred when cuffs were inflated with volumes of air exceeding 8 to 12 ml. The writers are familiar with two fatalities caused by asphyxia due to obstruction of the lumen of the endotracheal catheter by such bulging which was not recognized. The inferior edge of the cuff must not be close to the bevel of the catheter. The possibility of this complication is minimized if the lower border of the cuff is several centimeters from the end of the catheter. Soft rubber catheters may be compressed by excessive pressure, also. Both of these accidents may be avoided by first deflating the cuff, should additional air be required to effect a seal once the cuff has been inflated, and reinflating with a volume of air not to exceed 8–10 ml.
Aspiration

The cuff does not offer a perfect seal and fully protect against aspiration. The pack is equally as good or perhaps better. The obvious reasons for using a cuff are (1) to obtain a closed system so that positive pressure may be exerted to inflate the lung and (2) to prevent secretions from passing from the oropharynx into the trachea. Culver, Makel and Beecher (6) and Berson and Adriani (7) demonstrated by preoperative oral administration of dyes that regurgitation and aspiration may occur silently during anesthesia and that the anesthetist may be unaware of its occurrence. The incidence of such regurgitation is more frequent than one might suspect. Beecher and his associates noted that 76 per cent of the intubated patients they studied regurgitated. They employed the open oral technique. In other words, the endotracheal catheter was placed beneath the mask without a cuff or a pack. Aspirated material was identified in the trachea in nearly all of the patients who regurgitated into the pharynx. In a series of nearly 1,000 patients reported by Berson and Adriani (7), regurgitated material was identified in the pharynx in 25 per cent of intubated patients and recovered in the trachea in 14 per cent. Gauze packs moistened in physiological saline were used to attempt to effect a seal. This data indicates that the pack neither reduces the possibility of regurgitation nor does it insure against aspiration once regurgitation occurs. The incidence of aspiration into the trachea after regurgitation into the pharynx had occurred was the same in intubated and nonintubated patients. In neither Beecher's study nor in the one of Berson and Adriani (7) was the value of the cuff in preventing aspiration assessed. It appeared desirable, therefore, to obtain data on the efficacy of the cuff in preventing aspiration.

As in the previous study by Berson and Adriani (7) carmine red was administered orally in a capsule prior to anesthesia in 119 adult patients. Anesthesia was induced using ethylene followed by ether, cyclopropane followed by ether, thiopental followed by cyclopropane and then ether, and thiopental combined with nitrous oxide. Intubation using cuffed endotracheal tubes was facilitated in all instances by using single injections of 20–40 mg. of succinylcholine, intravenously. At the conclusion of anesthesia the pharynx was visualized with a laryngoscope and secretions were aspirated to identify the dye. The secretions in the endotracheal catheter were removed by aspiration. As was noted in the previous series, the incidence of regurgitation into the pharynx was 25 per cent. However, there was no incidence of aspiration into the trachea. In no case was there evidence of the dye in the trachea. Dye was recovered in the trachea of 2 patients not included in the series. In one vomiting occurred during induction before the catheter was introduced. In the other, the catheter was inadvertently inserted into the esophagus and aspiration occurred dur-
ing the realtempt at intubation. Obviously, the cuff assures against aspiration into the trachea even when regurgitation occurs into the pharynx.

Besides not guarding against aspiration, packing presents a number of major disadvantages over the endotracheal cuff. The pharyngeal and oral mucosa may be abraded by the gauze used for packing. The frenulum is lacerated during packing if the tongue is not firmly pressed to the floor of the mouth. Packing does not consistently afford a satisfactory closure and leakage of gas occurs when the breathing bag is compressed. Secretions often accumulate in the pharynx because the absorbent capacity of the pack is reduced by the petrolatum or saline used to moisten the gauze. Failure to remove packs at the conclusion of anesthesia, particularly when several have been used, is not an unheard of postanesthetic complication. Soft rubber catheters may be compressed by a tight packing.

Cardiorespiratory Reflexes

Inflation of the cuff stimulates noxious cardiorespiratory reflexes. The spasmodic bucking and coughing which occur as the cuff is inflated, particularly when anesthesia is light, is well known to those who have observed or attempted intubation. This is obviated or minimized by having the patient properly anesthetized, and by the topical application of local anesthetics to the pharynx and trachea prior to intubation and inflation of the cuff.

It is well recognized that cardiac irregularities are associated with intubation and endotracheal anesthesia (8). Reid and Brace (9) in 1940 called attention to irregularities associated with intubation. Since then, other reports, too numerous to discuss here, have appeared concerning arrhythmias associated with intratracheal instrumentation. The majority of reports are concerned with arrhythmias during the entire intubation procedure. Few reports deal with irregularities which specifically incriminate the cuff. Peterson (10) has described an instance of sudden cardiac arrest personally observed by him which occurred immediately after inflation of a cuff in a 28-year-old patient. Reid and Brace (9) mentioned the development of cardiac irregularities and electrocardiographic changes following the inflation of the endotracheal cuff in one of their patients.

In a study, recently completed at the Charity Hospital (11), continuous electrocardiographic records were made in 175 patients during and immediately after intubation. Seventy per cent showed some type of irregularity. The intubations were performed under a variety of conditions using catheters with and without cuffs, with packs and without packs during cyclopropane-ether, thiopental-cyclopropane or thiopental-nitrous oxide-succinylcholine anesthesia. The time of appearance of the irregularity could not be correlated with any maneuver associated with intubation. In some cases the irregularity appeared
before intubation was attempted; in others as the laryngoscope was passed into the pharynx; and in still others at the time the catheter was introduced. Five of 75 patients developed arrhythmias at the time of packing. Five of a group of 25 patients intubated with cuffed endotracheal catheters developed arrhythmias prior to inflation of the cuff. None developed arrhythmias as the cuff was being inflated or after inflation. No arrhythmias appeared, in spite of repeated, vigorous inflation and deflation of the cuffs, in these 25 patients. Likewise, repeated inflation and deflation caused no deviation of the electrocardiographic pattern existing at the moment prior to inflation in the five who developed irregularities. Peterson and Butterworth (10), in a series of 20 patients, observed no arrhythmias during intubation or at the time of inflation of the cuff. It must be conceded, however, since the exact cause of arrhythmias during intubation is not known, and, that they may be caused by stimulation due to instrumentation, that inflation of the cuff may be a causative factor. Nonetheless, it appears that, in the majority of patients, the use of a cuff does not appreciably enhance the severity of an existing arrhythmia or increase the incidence of arrhythmias. Suboxygengation during intubation has been incriminated as a possible precipitating factor in the development of arrhythmias. It is advisable to delay inflation of a cuff until the ventilatory pattern has been re-established and until all degrees of anoxia which may have developed during intubation, has been alleviated. It is the practice in this department to lubricate catheters with 20 per cent benzocaine (Americaine®) and instill 1 ml. of 4 per cent cocaine, or other topical anesthetic, into the catheter prior to inflation of the cuff, to obviate the reflex effects of mechanical stimulation.

VENTILATION

The cuff reduces the cross-sectional diameter of the trachea and interferes with ventilation. Beecher (12) has commented that large endotracheal catheters are undesirable and unnecessary and has suggested that a 32 French catheter be used routinely for all adults irrespective of size. He bases this contention upon data indicating that deviations in oxygen and carbon dioxide tensions do not occur when this suggestion is followed. Others disagree with this view, and contend that even though blood gas tensions are unaltered, an increase in ventilatory effort is necessary to maintain the status quo of the gaseous exchange. Obviously, since there appear to be arguments on both sides, this point needs clarification. Attempts were made to measure the effect of catheter size upon minute volume exchange and resistance to respiration in anesthetized patients. No data of any significance could be obtained because so many variable factors, many related to the operation, were involved. In order to eliminate variables and to obtain data under controlled conditions the study was done in the laboratory. An automatic mechanical ventilating apparatus was uti-
lized which consisted of an accordionlike bellows attached to a tube 2.4 cm. in diameter and 30 cm. long. The apparatus delivered fixed volumes of air (500 cc.) at a fixed rate (20 per minute). The tube served as an airway and accommodated the endotracheal catheter. A ventilation meter and a water manometer were interposed between the tube and the bellows (fig. 5). Impediments in ventilation, as the gases moved through or around the catheters and cuffs, were reflected by decreases in minute volume exchange, and increases in negative pressure on inspiration and positive pressure on expiration. The

![Graph]

Fig. 4. The increase in respiratory effort and the decrease in minute volume exchange which occurs when catheters of varying sizes are used with inflated cuffs in an 2.4 cm. airway. These data were obtained with a mechanical ventilator of the bellows type. The upper figures represent the increase in resistance in terms of negative pressure on inspiration in the bellows resulting from the decrease in cross-sectional area of the airway. The lower line represents the decrease in minute volume exchange expressed in per cent of the control, which occurs simultaneously with the increase in resistance.

effects of varying the sizes and designs of endotracheal catheters, with and without cuffs, were thus studied.

Cuffless catheters (Magill, silk woven, anode and plastic) irrespective of size, introduced some degree of resistance. Presumably this is due to the partial occlusion of the cross-sectional area of the airway by the cross-sectional area of the catheter wall. The resistance, as one would expect, became progressively greater as the tube decreased in size. In terms of negative pressure the resistance when a 40F catheter was used was 1 mm. of H₂O; when a 30F was used it was 4 mm. of H₂O. It must be noted that resistance increased when the
smaller catheters were used even though the space between the inside of the airway and the outside of the catheter increased progressively and permitted free passage of air. This is understandable because, as the lumen of a catheter decreases in diameter, turbulence plays an increasing role in restricting the passage of gases through the catheter. Thus, from both a theoretical standpoint and that of actual figures, it is incorrect to assume that the flow of respired gases is not restricted when an undersized catheter is employed. Thus, the use of an undersized catheter in a patient, even if one could be assured that the vocal cords are relaxed and offer no impediment, and one does not

![Diagram](image)

**Fig. 5.** Arrangement for measuring resistance to respiration offered by endotracheal catheters. The mechanical ventilator is set to deliver the desired minute volume exchange. Changes in resistance to passage of gases are reflected by alterations in negative pressure on inspiration and positive pressure on expiration on the manometer or by changes in minute volume exchange or by changes in both pressure and minute volume exchange.

always have this assurance, restricts ventilation. It must be admitted, though, that from the standpoint of actual clinical practice, the impedance offered by an undersized catheter used beneath the mask in the usual adult surgical patient, free from pulmonary insufficiency, is of little or no major consequence.

Beecher (12) further suggests routinely using a 34F catheter when a pack or cuff are desired. Light packs placed around the catheters in the ventilating apparatus caused significant increases in ventilatory effort and reductions in minute volume exchange. Inflation of the cuff caused still greater significant interference with ventilation. An average decrease in minute volume exchange of 7 per cent and a negative pressure of 10 mm. of H₂O were observed when a 30F
catheter with an inflated cuff was substituted for a 40F. With the 40F the reduction in ventilation was 1 per cent and the resulting negative pressure 2.5 mm. of H₂O after inflation. It is obvious (fig. 4) that the smaller the catheter the greater the decrease in cross-sectional area of the trachea caused by the catheter and the inflated cuff. The measurements when deflated cuffs were studied were similar to those obtained with uncuffed catheters.

This data merely corroborates what one would ordinarily surmise by using common sense; namely, that the largest possible catheter with the thinnest noncollapsible wall which can be easily introduced into the trachea, without force, is the most desirable and the one which assures the least interference with ventilation.

**Drainage of Secretions**

*The cuff does not permit free drainage of secretions from the trachea into the pharynx.* When the head-down position is used for patients who have suppurative diseases of the lung, secretions slowly trickle along the wall of the trachea. Ordinarily these accumulate in the pharynx. Beecher (1) contends that, during thoracic surgery, the cuff is responsible for pooling of secretions in the trachea and spillage of purulent material into the nondiseased lung. One cannot deny that secretions do drain down the tracheal wall under such circumstances and that these accumulate in the pharynx when uncuffed catheters are used. How serious this accumulation of secretions is and to what extent it occurs is a matter of question. In order to determine the extent of this pooling, cuffed catheters of various sizes were inflated in glass tubes in the manner described previously. A colored gelatin solution was allowed to drain into the tube which was inclined at various angles until it appeared in the lumen of the catheter. A suction catheter was then introduced and as much of the colored solution as possible was aspirated. The cuff was then deflated and the solution which had accumulated and had not been drawn into the aspirating catheter was collected and measured. The quantity obtained varied considerably. However, the results of the study confirm as one would normally surmise, that the farther the cuff is placed from the end of the catheter the greater the volume of solution which accumulates. The smaller the diameter of the catheter, in relation to the diameter of the trachea, the greater the volume of accumulated secretions. The greater the angle of inclination the greater the quantity of secretions retrieved. For example, when a 36F catheter with a cuff 3 cm. in length with the inferior border 2 cm. from the bevel was inclined 15 degrees—1 ml. of fluid was retrieved. When the tube was inclined at an angle of 30 degrees—2.5 ml. was retrieved, at 45 degrees—4 ml. The nearer the horizontal the catheter was placed the less the pooling. One must not overlook the fact that when the patient is in the supine position,
the trachea is inclined in a posterior and caudad direction. The accumulation of secretions around the catheter under those circumstances is no problem. It is when the steep head-down positions are used that this pooling becomes a factor. In those situations one must use catheters with cuffs placed close to the bevel. In addition catheters should not be introduced too far into the trachea.

**Summary**

A laboratory and clinical study of endotracheal cuffs has been undertaken. The observations made and the data obtained lead to the following conclusions:

Pressures necessary to inflate the conventional endotracheal cuffs and to effect a seal, when the breathing bag is compressed manually to develop pressures between 15 and 20 mm. of Hg in a circle system, range between 90 and 220 mm. of Hg. The wide variations in pressure are due to the differences in size of cuffs, the volumes of air necessary to inflate the cuffs, the distance between the wall of the catheter and the interior of the trachea, and the thickness and elasticity of the rubber composing the cuffs. Most of the pressure is expended in overcoming the elasticity of the rubber. The pressure exerted by the cuff on the tracheal wall varies between 10 and 15 mm. of Hg when inflated to hold pressures ranging between 15 and 20 mm. of Hg in the breathing bag.

The possibility of severe trauma, contusions and laceration of the trachea, bronchi, or alveoli by rupture of a cuff under ordinary usage has been grossly exaggerated. Ordinarily, less than 10 ml. of air are necessary to inflate most cuffs. Volumes of 40 ml. or more are necessary to cause rupture. Intracuff pressures, when such volumes are used, exceed 1,000 mm. of Hg. Rupture of cuffs under such circumstances caused no discernible trauma to the trachea, bronchi or lung of dogs.

The incidence of cardiac arrhythmias, and reflex circulatory disturbances is no greater with cuffed than with uncuffed catheters. There is no correlation between the act of inflating the cuff and the development of cardiac arrhythmias.

The cuff is 100 per cent effective in preventing the aspiration of gastric contents from the pharynx into the trachea. The pack does not assure against aspiration. The incidence of aspiration when the pack is used is identical to that which occurs when intubation is done without a pack or a cuff.

The routine use of a single sized endotracheal catheter for all patients, say for example, a 32F, without a cuff results in a decrease in minute volume exchange and an increase in ventilatory effort. This resistance increases progressively as the diameter of the catheter is decreased in an airway of constant internal diameter. Under simi-
lar circumstances, using a catheter with an inflated cuff, a simultaneous increase in ventilatory effort corresponding to a negative pressure of 10 mm. of H₂O and a reduction of minute volume exchange of 7 per cent occurred when a 30F catheter was used. The negative pressure which developed using a 40F was 2.5 mm. of H₂O and the decrease in minute volume exchange was less than 1 per cent.

Pooling of secretions between the tracheal wall and catheter in the area distal to the inferior edge of the cuff occurs only when the steep head-down position is used and the edge of the cuff is at an appreciable distance from the end of the catheter.

REFERENCES


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Dr. Robert D. Dripps, Professor and Chairman, Department of Anesthesiology, University of Pennsylvania, Philadelphia, Pennsylvania, was elected a Director of The American Board of Anesthesiology at a meeting of the Board in Coronado, California, October 24, 1956. Dr. Dripps was elected to the vacancy created by the resignation of Dr. Meyer Saklad of Providence, Rhode Island.