Technical Report

A study of tape adhesive strength on endotracheal tubes

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A method of assessing the adhesive bond of tapes used to secure endotracheal (ET) tubes is described. Five kinds of tape and six different ET tubes including two silicone rubber, wire-reinforced tubes were tested. There are significant differences in the adhesive strength of different tapes, and in the adhesive bond formed by different ET tube materials. On the Portex clear ET tube, silk tape adhered best ($p < 0.001$), followed by waterproof, cloth, dermiclear, and micropore tapes. Adhesive bonding by silk tape was significantly greater ($p < 0.001$) for the three clear ET tubes (Portex clear, NCC clear, and Portex ivory) than for the Portex blue and the silicone rubber, wire-reinforced ET tubes. All tapes showed very poor or negligible adhesion to the Sheridan and Portex reinforced ET tubes. Adhesion to these tubes was greatly improved by wrapping them tightly with an "op site" dressing prior to applying tape.

A well secured endotracheal (ET) tube is an extremely important aspect of safe anaesthesia, particularly in paediatric patients in whom the distance from the mid trachea to the cords or carina is short. Securement of the ET tube is usually accomplished by taping it to the patient's face.

Several techniques claiming to improve adherence of tape to ET tubes have been described[1–3] but a systematic study of the adhesion between various tapes and different ET tubes has not previously been done. We have noted particular difficulty in securing silicone rubber, wire-reinforced tubes. This very poor adherence by tape to armoured tubes has not been adequately stressed in the literature.

We describe a simple technique of objectively measuring the adhesion between a variety of tapes and different ET tubes. This may provide a more rational basis for the selection of an adhesive tape to secure any given ET tube.

Key words

COMPLICATIONS: accidental extubation; EQUIPMENT: endotracheal tubes.

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Methods

The ET tube to be tested was firmly attached to a rigid support. Paper templates of uniform size (15 mm × 40 mm) were produced with a standard area (5 mm × 15 mm) excised from the middle (Figure 1).

These excised areas were completely covered with pieces of the tape to be tested, which were larger than the cut area but smaller than the template. In this way, the tape was firmly adherent to and not overlapping the paper template, and a known constant area of each adhesive tape surface (5 mm × 15 mm) was exposed. Great care was taken to prevent any contact or handling of the adhesive surface that would ultimately be applied to the ET tube.

The paper template was applied to the ET tube and held there by the centrally exposed area of adhesive tape. A paediatric blood pressure cuff was positioned around the applied template, the ET tube, and the rigid support, and inflated to 300 mmHg for 20 seconds before deflating the cuff (Figure 2). Thus each piece of tape was applied to the ET tube in a standard manner.

A line connected over a single pulley to a weight was used to apply a constant distracting force to the lower free edge of the paper template. The time (in seconds) from the moment the weight was applied until complete tape release was determined. This time was used as the measure of adhesive strength.

Ten trials were performed for each different tape and ET tube combination. To prevent accumulation of adhesive particles on the ET tube, it was cleansed with an alcohol swab and allowed to dry between trials. This did not seem to affect the surface characteristics of the ET tube as judged by the consistent adhesive properties over time with each tape. The results were analyzed using a

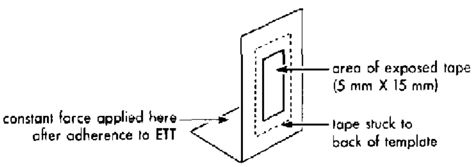

FIGURE 1 The paper template showing uniform dimensions of exposed tape.

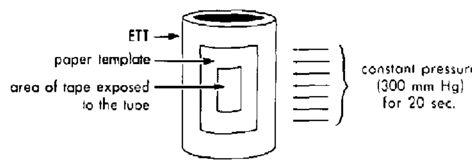

FIGURE 2 The template carrying a uniform exposed area of tape is applied to the ET tube under identical conditions of time and pressure.

two-tailed Student's t test. The mean and standard deviation of each trial were calculated.

We tested six different ET tubes made by three different manufacturers (Portex, National Catheter Corporation and Sheridan): (1) Portex – clear PVC (Blueline 7.0 mm Magill tube, Lot No 43008), (2) NCC – clear PVC (7.0 mm Mallinckrodt tube, Lot No 4C067A1), (3) Portex-blue (7.0 mm Magill tube, Lot No 5C050), (4) Portex ivory (7.0 mm Lot No 5D072), (5) Portex-reinforced silicone tube (7.0 mm Lot No 3C001) and (6) Sheridan reinforced silicone tube (7.0 mm Lot No 12-0833-11).

We examined five different types of commonly available tapes: (1) Waterproof (Plastic adhesive tape, waterproof; Smith and Nephew Inc, Lachine, Quebec); (2) Silk (Nichisilk; Nichiban, Surgical Tape No 41, Gainor Medical, Edmonton, Alberta); (3) Dermiclear (Transparent tape; Johnson and Johnson); (4) Cloth (Curity adhesive tape, 12 mm, 11517; Kendall Inc, Toronto, Ontario); and (5) Micropore (Micropore Surgical Tape No 1530; 3M Medical Products Division, St. Paul, MN).

The same model was used to investigate the effect of four different procedures designed to improve adherence between the silicone rubber tube and tape. Tests were performed on the adherence of silk tape to tubes previously treated with Friars Balsam (compound benzoin tincture, SEL-WIN Chemicals Ltd, Vancouver, B.C.), or with skin bond cement (HRI 8026-4000-00, Canadian How Medica Ltd) and allowed to dry prior to testing. Silicone rubber tubes were also wrapped tightly with silk suture material,[3] or circumferentially wrapped with an "opsite" dressing (Smith and Nephew Inc., Lachine, Quebec) over the area to which the tape would be applied.

Results

There were differences between the adhesive bond provided by different tapes when applied to an ET tube, and between the same tape applied to different tube materials. These are summarized in the Table.

Comparing the adhesive strength of the five different tapes applied to the Portex clear ET tube, the silk tape was significantly better ($p < 0.001$) than all the others. Waterproof tape was the next most adherent, whereas Dermiclear, cloth and Micropore show uniformly poor adhesive strength to this ET tube (Figure 3).

The ET tube material also influenced the strength of binding for a given tape. Comparing the adherence of silk tape to the six different ET tubes, the three clear tubes (Portex clear, NCC clear, and Portex ivory) have similar adhesion, greater ($p < 0.001$) than the Portex blue and the Sheridan reinforced tubes. Adherence of any tape to the Portex reinforced tube was minimal (Figure 4).

Comparing the adhesive strengths of all tape and ET tube combinations, a similar pattern emerged. Silk tape had the strongest adherence to the three clear ET tubes, the next strongest was waterproof tape, and the other three tapes showed uniformly poor adhesive strength.

With the Portex blue tube, waterproof tape had superior adherence, followed by silk tape, and again the other three tapes showed poor adhesive strength.

TABLE Time to separation (seconds ± SD) for different tapes and endotracheal tubes

	Tape				
Tube	*Silk*	*Waterproof*	*Dermiclear*	*Cloth*	*Micropore*
Portex clear	200 ± 80	36 ± 17	9 ± 2	11 ± 14	10 ± 5
N.C.C. clear	106 ± 44	36 ± 6	6 ± 2	3 ± 2	3 ± 2
Portex ivory	101 ± 39	32 ± 7	8 ± 3	5 ± 4	2 ± 1
Portex blue	28 ± 16	101 ± 37	6 ± 2	8 ± 6	1 ± 1
Sheridan reinforced	33 ± 10	20 ± 4	4 ± 2	3 ± 2	4 ± 3
Portex reinforced	0	0	0	0	0

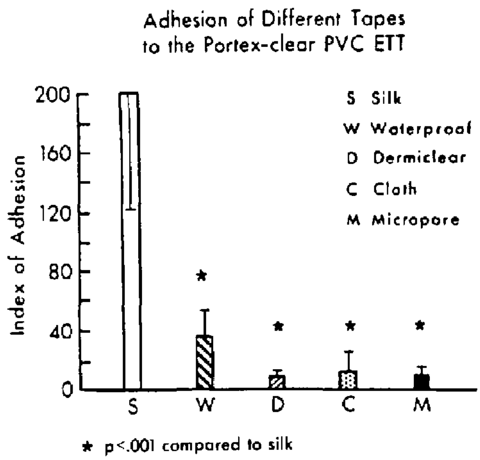

FIGURE 3 Adhesion of different tapes to the Portex clear ET tube (mean and standard deviations).

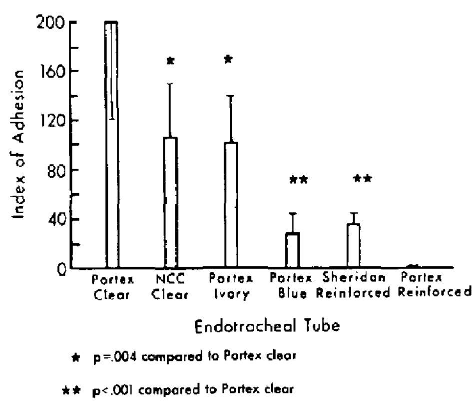

FIGURE 4 Adhesion of silk tape to different ET tubes (mean and standard deviations.

There was uniformly poor adherence by every type of tape to the Sheridan reinforced tube and a complete lack of adherence to the Portex reinforced tube.

The technique of pretreating the silicone rubber, wire-reinforced tubes with either tincture of benzoin, skin bond cement or silk suture material[3] failed to improve adherence of silk tape. However, wrapping these tubes with an "op-site" dressing before applying tape markedly improved the adhesive bond. After the tape was applied to the "op-site" surface, an extremely strong bond was formed. The tape was firmly stuck to the "op-site" cover which was itself tightly bound to the ET tube due to its own adhesive properties as well as the pressure exerted circumferentially. Once tape was applied in this way, it was so firmly adherent that the force used in testing could not separate it.

Discussion

We believe that the model we have developed for testing adhesive strength between a given tape and ET tube provides a clinically significant indication of the ability of that tape to secure the ET tube. We have found that there are significant differences between tapes in their ability to adhere to an ET tube.

The endotracheal tubes also showed significantly different adhesive characteristics. Most striking was the poor adhesion of any tape to silicone rubber, wire-reinforced ET tubes. Adhesion to the Sheridan reinforced tube was very limited, while to the Portex reinforced tube adhesion was negligible. As these ET tubes are frequently used during anaesthesia for neurosurgical and head and neck surgery, this finding is important.

There are obviously some limitations to the tests that we have performed. All testing was done at room temperature and humidity, and therefore cannot predict what might occur as the tube warms to body temperature or is exposed to moisture. Only the adhesion between tape and tube was tested, and not that between tape and skin. Adhesion to skin is obviously an equally important factor in the secure fixation of tubes, but with many differing skin properties is much more difficult to quantitate. Despite these limitations it is considered that our tests have demonstrated differences in adhesive bonds between different tapes and tubes which are of clinical importance.

In conclusion, we have described a method to measure the degree of adherence between different tapes and ET tube materials and have assessed various tape and ET tube combinations. Silk or waterproof tape provided the most secure adhesive bond. We have found that commonly used adhesive tapes do not adhere to silicone rubber, wire-reinforced tubes.

It is suggested that, before taping a silicone rubber, wire-reinforced tube to a patient's face, the ET tube be tightly wrapped with an "op-site" dressing and the tape be applied over this. We have used this technique clinically in many cases and found it to be very satisfactory.

References

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2 *Klein DS.* An endotracheal tube fixation device constructed from discarded oxygen tubing and umbilical tape (Letter). Anesthesiology 1984; 70: 76.
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Résumé

Une méthode d'évaluer la force adhésive des diachylons utilisés pour maintenir les tubes endotrachéaux (ET) est décrite. Cinq types de diachylon et six différents tubes endotrachéaux incluant deux silicones caoutchoutés et renforcés ont été étudiés. Il y a des différences significatives dans la force adhésive des différents diachylons et dans le lien d'adhésion formé avec le matériel des différents tubes endotrachéaux. Sur le tube endotrachéal clair type Portex, un diachylon en soie adhère le mieux ($p < 0.001$) suivi par le diachylon imperméable, en tissu, dermiclear, et micropore. Le lien d'adhésion par le diachylon en soie était significativement plus grand ($p < 0.001$) pour les trois tubes endotrachéaux (Portex clear, NCC clear, et Portex ivoire) que pour le portex bleu et le silicone caoutchoutés et renforcés. Tous les diachylons ont démontré une adhésion faible aux tubes endotrachéaux Sheridan et Portex réenforcés. L'adhésion à ces tubes était améliorée énormément lorqu'on les a entourés d'une façon étanche avec un pansement "op site" avant l'application du diachylon.