The Insecure Airway: A Comparison of Knots and Commercial Devices for Securing Endotracheal Tubes

Paris B Lovett

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BACKGROUND: Endotracheal Tubes (ETTs) are commonly secured using adhesive tape, cloth tape, or commercial devices. Adhesive and cloth tape have been reported equally effective, but there has been no experimental comparison of cloth tape tied with different knots. Movement of an ETT by as little as 3 cm may be life-threatening.

OBJECTIVES: To compare rates of failure of the following methods: cloth tape tied with 3 different hitches; Cow Hitch (Cow), Clove Hitch (Clove), and Magnus Hitch (Magnus); nasal cannula tubing tied with a Clove Hitch (NC); and 6 commercial devices: Comfit™ (Ackrad), Stablittube™ (B&B Medical), E-TAD™ (Hollister), Thomas™ ST (STI Medical), and Dale® ETT Holder.

METHODS: A 17 cm diameter PVC tube with 14 mm “mouth” hole in the side served as a mannequin. 1.25 cm synthetic twill was used for cloth tape. ETTs were secured with cloth tape, nasal cannula tubing or devices and subjected to repeated jerks. The jerks were performed for each knot/device. All devices were applied according to the manufacturers’ instructions. All knots and devices were wet with saline. Failure was defined as movement > 3 cm.

RESULTS: 3 types of failure were identified: slip, stretch and breakage. Among commercial devices, all devices failed consistently either at 2.5 lbs (12 jerks) or 5 lbs (6 jerks), with the sole exception of the Dale®, which consistently passed both tests (p < 0.01). All devices, including the Dale®, failed at loads >10 lbs. Cloth tape never broke; all failures were stretch or slip. Stretch failure was similar for all knots, averaging 5 cm at 10 lbs (6 jerks). Isolating out slip failure, and comparing among the knots, Magnus and Clove produced less average slippage than the Cow, but the differences were not significant. NC produced almost no slip (average < 0.25 cm) but unacceptable stretch occurred: 3.25 cm at 5 lbs (6 jerks).

CONCLUSIONS: Among devices, for dynamic loads > 5 lbs, the Dale® was most secure. Cloth tape breaks less easily than all commercial devices tested, but suffers from slippage and stretch. Development of a new cloth tape material, with improved grip and reduced stretch would markedly reduce failure. Nasal cannula tubing has excellent grip but stretches too much to be recommended.

The authors would like to thank the manufacturers, who donated devices for testing, as well as Mallinkrodt which donated the endotracheal tubes used in the study. It is important to note that our testing protocols differ from FDA testing requirements, which are satisfied by all the devices in this study. Some manufacturers told us that they meet FDA testing requirements using static pull tests, not dynamic jerks. Manufacturers stressed the low numbers of reported extubations that have occurred with their products. It is of course difficult to know what percentage of unplanned extubations are reported to manufacturers.

The idea behind this study was to replicate the jerking of an agitated, under-sedated emergency patient. This is why we chose dynamic jerks. It is possible that this testing exceeds the requirements of real-life practice in the ED, but it is also possible that FDA requirements do not meet the needs of the ED.

Other than donation of devices, the authors received no support or assistance from any medical device company. Numbers of tests varied between devices, but in all other respects testing protocols were applied uniformly.

Finally, let us note that this study did not examine other qualities which are important in any endotracheal tube securement method, such as patient comfort, provision for oral hygiene, and avoidance of trauma to facial and oral tissues.