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Development and Evaluation of an Internet-Based Airway Evaluation Tutorial

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***Abstract*:** Airway evaluation and basic management are essential skills for all physicians. Identifying patients for whom mask ventilation or endotracheal intubation will be difficult to impossible is vital for patient safety. Despite this, training in airway evaluation is minimal in the curricula of most medical schools. To ensure a thorough understanding of airway anatomy and evaluation, as well as exposure to various abnormal findings, we developed an Internet-based module including interactive components, graphics, animation, video, and a self-assessment tool. The site received more than 1800 visits in its first nine months of operation, with uniformly laudatory comments. Eighty subjects over a six-month period completed a pre- and post-test quiz structured to evaluate the utility of the site. Of those completing the on-line survey, more than 76% rated the site *very useful*. Most felt their knowledge of airway examination improved after completion of the site ($p<0.00004$). The median amount of time spent on the site was 29.5 minutes. Judging from the overwhelming response to this site from around the world and across disciplines, such interactive training tools that exploit the technological capabilities of the Internet provide useful adjuncts to traditional teaching methods.

Keywords: Education; Airway Evaluation; Internet-based Education

Airway evaluation and basic management are essential skills of all physicians.[1,2] The ability to identify patients for whom mask ventilation or endotracheal intubation will be difficult to impossible is vital for patient safety. In fact the American Medical Association's policy on Advanced Cardiac Life Support Training encourages medical schools to include, "airway anatomy and function" and "airway management and intubation in the unconscious patient."[3] Despite this, training in airway evaluation is minimal in the curricula of most medical schools. Although Departments of Anesthesiology are the logical educators on this topic, in 2002 (the last year for which complete data is available) less than 25% (30 out of 126) of US medical schools required exposure to anesthesiology.[4] Thus most graduating medical students likely receive inadequate training regarding airway evaluation and management. At the University of Florida we introduce the airway examination during a two-week exposure to anesthesiology in the fourth year of medical school. To ensure a thorough understanding of airway anatomy and evaluation techniques, and exposure to various abnormal findings, we developed an Internet-based module including interactive graphics, animation, video, and a self-assessment tool. Here we describe the development of this educational site (http://www.anest.ufl.edu/at) and report the results of an investigation into its utility.

Methods

Project Definition - Two of the investigators (TYE, AIL) determined learning objectives for the module:

- name all significant airway-related structures in the pharynx and neck
- list the innervation of the pharynx
- perform a thorough airway examination
- identify and recognize the presence of risk factors for difficult endotracheal intubation
- describe the airway management of a high-risk patient

We selected a case-based presentation technique, with a menu-system at the margin, to allow immediate jumps to specific topics. We sought to maximize

interactivity, and employed images and animations wherever possible.

Site Development - We divided the content into several case presentations, each with specific teaching points:

1) A healthy patient with normal airway for emergency appendectomy
   a. Aspiration of gastric contents, and prevention
   b. Airway examination: mouth opening, Mallampati classification, predictors of difficult intubation
   c. Positioning for intubation
   d. Direct laryngoscopy
   e. Laryngoscopy grades
2) An otherwise healthy patient with a small chin
   a. Innervation of the upper airway
   b. Basics of airway blocks
   c. Detailed airway anatomy (CT and fiberoptic cross-sectional images)
3) A trauma patient with a potentially unstable cervical spine for repair of an open femur fracture
   a. Cervical spine anatomy
   b. Neck movement with direct laryngoscopy
   c. Evaluation of the cervical spine, including the "Nexus" criteria[5]

Tasks included: writing the text components, including hypertext to define terms and interactive quizzes; identification and drawing of necessary images; collection of appropriate patient photographs; development of aspiration animation; fiberoptic endoscopy of a volunteer; collection of radiographic images; and video of laryngoscopy on a simulator (HPS, METI Inc., Sarasota, FL). An engineering student implemented the site using Dreamweaver 4 (Macromedia, San Francisco, CA), with Java for the interactive components as needed. A medical student with graphic skills created the aspiration animation using Adobe Illustrator and Photoshop (Adobe Systems Inc, San Jose, CA). A comments page, requested input from users upon completion of the site. Funding through the College of Medicine Education Committee supported the programmer and graphic artist. The Website (http://www.anest.ufl.edu/at) is freely accessible.

Faculty and residents in the Department of Anesthesiology reviewed the site, and their suggestions were incorporated. Finally a link to the Airway Evaluation Website was added to the Department of Anesthesiology Home Page, and completion of the site was required of all fourth year medical students during their required two-week anesthesiology clerkship in 2002-3. To ensure completion, an examination link at the end of the site directed students to the medical education server, which requires a student-specific login.

Site Evaluation Study - Following Institutional Review Board approval, we implemented a pre- and post-test study. The pre-test consisted of a survey question regarding the subject's pre-existing knowledge of the airway examination ("Thorough, Adequate, Marginal, None") and three questions related to the airway evaluation of a pictured patient (Mallampati classification, mouth opening and mental-hyoid distance). The post-test contained identical items, with the addition of a question regarding utility of the site ("Very helpful, Somewhat helpful, Not helpful"). The pre- and post-tests are linked by user input of their email address (a unique identifier) on both tests.

Statistical evaluation of responses to the knowledge level question was performed with the Wilcoxon matched pairs test. Airway evaluation scoring was compared using the Wilcoxon sign test.

Results

Between June 2002 and May 2003, the site received more than 1800 "hits." The comments feature was used 3-4% of the time, with uniformly complimentary statements. In addition to anesthesiologists, anesthesia residents, nurse anesthetists and nurse anesthesia students, comments have been received from pharmacists, medical students, and surgeons, and from as far away as Europe, Indonesia, and South America.

The study examination was not added until several months into the project. By May, 2003, 168 pre-tests and 103 post-tests were submitted. Many individuals failed to include their email address, or other unique identifier, on both exams, and their data were excluded. The remaining 80 unique subjects were included for data analysis (table). Other than obtaining their *a priori* self-assessment of airway evaluation skills, their occupation and level of training were not requested as part of the study.

On the pre-test, 47 subjects (59%) claimed an adequate or thorough knowledge of the airway evaluation, while on the post-test this number rose to 76 (95%). Overall, subjects felt their knowledge level improved ($p=0.00004$). Evaluation of the example patient's airway was altered by review of the site, though not a statistically significant improvement: Mallampati classification (98% correct post-vs 80%

Table 1 - Results of pre- and post- tests.

	Pre-Test	Post-Test
Knowledge		
Thorough	10 (13)	34 (43)
Adequate	37 (46)	42 (53)
Marginal	27 (34)	3 (4)
None	2 (3)	0 (0)
Mallampati Class		
3 or 4	64 (80)	78 (98)
1 or 2	7 (9)	1 (1)
No idea	9 (11)	1 (1)
Mouth Opening		
Normal	49 (61)	43 (54)
Reduced	29 (36)	37 (46)
No idea	2 (3)	
Mental-Hyoid Distance		
Normal	1 (1)	2 (3)
Reduced	73 (91)	78 (98)
No idea	4 (5)	0 (0)

Note: n=80; numbers in parentheses are percentages.

pre-test), mouth opening (54% post-vs 61% pre-test), and mental-hyoid distance (98% post- vs 91% pre-test).

Using the time-stamps from the pre- and post-tests, the median amount of time spent on the website was 29.5 minutes (range 0-168). Three subjects submitted the pre- and post-tests at the same time, with three others spending <10 minutes. Still others took the pre- and post-tests on different dates (excluded from the maximum calculation). Thus the median is a more realistic measure than average for these data.

Subjects graded the utility of the site by answering the question, “Was this web site helpful?” with three choices of “Very,” “Somewhat” and “No.” All but one of the respondents found the site very helpful (76%) or somewhat helpful (23%).

Discussion

Any physician may be expected to care for an unconscious patient requiring airway management. The increasing use of conscious sedation for office-based procedures accentuates this issue. The ability to anticipate the potential for particular difficulty with certain patients is essential for all physicians. If recognized in advance, sedative selection may be altered, specialty assistance requested earlier in an emergency, and selection of agents to facilitate intubation would certainly be changed (e.g., avoidance of the routine long-acting muscle relaxants).

Despite the fact that all physicians *should* be able to manage the airway of an unconscious patient, only anesthesiologists and emergency medicine physicians are routinely, formally trained in airway evaluation. At the University of Florida there is a two-week required anesthesiology clerkship in the fourth year of medical school. During this course, the students receive formal training in airway management consisting of didactic sessions, practice with manikins, and hands-on experience paired with an anesthesiology resident in the operating room. Unfortunately that experience varies widely with the teaching skills of the resident, the interest of the medical student, and the caseload during their brief tenure. The airway examination is often lost amidst the desire to perform procedures. Thus the investigators endeavored to produce a thorough, readily accessible teaching tool for the airway examination.

Use of the Internet for teaching has expanded rapidly in the last decade. In addition to numerous brief descriptions of various sites[6,] Internet-based teaching tools have been developed and investigated for use in radiology[7,8], geriatrics[9], dermatology[10], genetic testing[11] and pathology.[12] All have been well-received as a supplement to traditional teaching. While not proven *superior* to traditional teaching methodologies from an educational standpoint, ample evidence exists that Web-based learning can be at least as effective.[13]

Use of high tech tools for education has become commonplace in anesthesiology, where sophisticated human patient simulators are integrated into many curricula.[14,15] While these models provide an excellent environment for practicing airway management techniques, the manikin's external anatomy does not change, thus the abnormal airway examination cannot be adequately simulated. For this we exploit the flexibility, availability and low end-user cost of the Internet.

During the site-development phase, a search of existing resources on the Internet (using terms airway evaluation, airway assessment, airway examination) identified multiple sites with a text-based description of the steps in airway evaluation. Many academic centers had such a site, but none took significant advantage of the Internet’s versatile tools such as incor-

poration of hypertext, interactive images, animations, or scripting technology. Furthermore none incorporated a review of basic anatomy. The developed site, while containing much of the same information, exploits these capabilities. In particular the interactive features were highly regarded in many of the comments received, "the topics presented here have all been presented during this rotation (at another institution), however, the interactive aspect of your tutorial made the material easier to visualize and understand," "Excellent interactive website in both format and content. [It] helped to reinforce important concepts from prior reading and [the] quizzes were also beneficial. Great interactive tool overall; wish more courses had this type of additional interactive activity to supplement clinical education."

Utility Study - The pre- and post-tests focus on the same case: a thin female patient with <2 fingerbreadths mentum-hyoid distance, and limited mouth opening with a Mallampati Class IV airway. Unfortunately the photographs are not perfect. There is no scale (e.g. hand) next to the open mouth to demonstrate its limited size, and the shadows in the posterior pharynx give the impression the base of the uvula may be visible. Furthermore, in the presence of such a patient, most would adjust their viewing angle repeatedly in an effort to obtain the optimal view. Thus it may be disputable whether, from this single photo, the airway is a Class III or IV; but it is clearly not a I or II. Similarly it is not entirely obvious whether the mouth opening is "normal" or "reduced." There is no question, however, that the mentum-hyoid distance is short (as demonstrated by a hand under the chin).

The design of the site does not force users to participate in the study. Their responses are recorded only if they choose to submit them. In order to link the pre- and post-test scores, a unique identifier was required; the subject's email address was selected. Unfortunately many are reluctant to provide this information, probably in fear they will receive unwanted email in response. In retrospect, another identifying option should have been offered, or a more sophisticated software system that linked the two tests anonymously.

We successfully developed a Website to teach the fundamentals of the airway examination. Unlike other sites on this topic, this airway evaluation tutorial functions as much more than an electronic handout; it exploits the interactive, animation, and graphical potential of the Internet to present an engaging educational experience. Users of this site have found it entertaining and educational. A common theme in the literature regarding such sites, many of the users, as well as the authors, recommend a similar approach to other medical topics, as an adjunct to traditional teaching techniques.

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