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Hands-on Pulmonary Curriculum: Interactive Learning Sessions on Oxygen Delivery, Spirometry, Positive Airway Pressure Devices, Tracheostomy, and Thoracostomy Tubes

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Abstract

Introduction: Pulmonary equipment has become ubiquitous in clinical care. Basic device troubleshooting and mechanical manipulation skills are crucial to the practicing physician yet are frequently neglected in standard pulmonary curricula. **Methods:** We developed a hands-on pulmonary curriculum for medical residents and students, focusing on oxygen delivery, spirometry, positive airway pressure devices, thoracostomy, and tracheostomy knowledge. The curriculum, consisting of five 1-hour sessions, offers hands-on experience with basic pulmonary equipment relevant to the ICU and/or pulmonary clinic. Each session is led by a pulmonologist or critical care facilitator and designed for a learning audience of 10-15 internal medicine trainees and medical students. More than 11 sessions have been conducted since curriculum implementation. **Results:** Voluntary, immediate, pre- and postsession surveys assessed objective subject knowledge, perceived subject understanding, and perceived effectiveness of this hands-on format versus a conventional lecture style. A total of 52 learners returned surveys. Aggregate responses demonstrated that these sessions were typically the first formal training learners had received in these subject areas. Subject knowledge and perceived level of subject understanding both improved, and respondents reported the hands-on style of teaching was more effective than conventional lecture format. **Discussion:** Focused on practical knowledge, this pulmonary hands-on curriculum addresses a knowledge gap for medical trainees, has been enthusiastically received by trainees, and provides a useful resource for faculty wishing to teach about these devices.

Keywords

Pulmonary Devices, Supplemental Oxygen, Spirometry, Positive Airway Pressure Devices, Tracheostomy Tubes, Thoracostomy Tubes

Educational Objectives

By the end of the module, learners will be able to:

1. Describe the variables impacting FiO_2 delivery.
2. Categorize oxygen delivery devices as low or high performance.
3. List indications for high-performance devices.
4. Instruct a patient on how to perform a forced vital capacity maneuver.
5. Recognize unacceptable spirometry maneuvers.
6. List limitations of spirometry.
7. Identify the most common uses of positive airway pressure (PAP) therapy encountered in general outpatient medical practice.
8. Describe the differences between continuous PAP and bilevel as well as their major uses.
9. Perform a basic interpretation of a PAP download to assess usage and efficacy.
10. Identify the components of a tracheostomy tube.

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Appendices

A. Oxygen Delivery Devices Instructor Guide.docx
B. Spirometry Instructor Guide .docx
C. PAP Devices Instructor Guide.docx
D. PAP Downloads A-C Blank .pdf
E. PAP Downloads A-C With Hints.pdf
F. PAP Downloads A-C Instructor Answers.pdf
G. Tracheostomy Instructor Guide.docx
H. Tracheostomy Challenge Questions.docx
I. Thoracostomy Tubes Instructor Guide.docx
J. Oxygen Delivery Devices Survey.docx
K. Spirometry Survey.docx
L. PAP Devices Survey.docx
M. Tracheostomy Tubes Survey.docx
N. Thoracostomy Tubes Survey.docx

All appendices are peer reviewed as integral parts of the Original Publication.

11. Identify the differences between sizes and types of tracheostomy tubes.
12. Describe the function and indications of a Passy-Muir valve.
13. Describe the chest tube collection system.
14. Troubleshoot a malfunctioning chest tube collection system.
15. List decision-making steps in removing a chest tube.

Introduction

The correct use of pulmonary equipment requires both cognitive and technical skills.[1,2] In addition to interpreting results, manual manipulation of equipment is often needed in order to optimize its use and/or safety for patients.[3] Examples of this include demonstration of correct spirometry[4] technique and management of emergency situations with tracheostomies.[5] Both our personal experience and prior studies indicate that medical trainees are rarely taught the skills of troubleshooting and managing the devices themselves or how this impacts the data collected or care of the patient.[6]

This curriculum was inspired by the popularity of the first of these hands-on lectures at our institution. Specific topics were chosen based on learning needs observed in the ICU and in clinic. We searched MedEdPORTAL and various curriculum repositories and did not find any curricula available on these topics. Therefore, we developed this curriculum to address the lack of knowledge and hands-on familiarity with pulmonary and critical care equipment among trainees at our institution. We wanted to create materials that would allow any member of the group, or other appropriate faculty, to lead any of the sessions. Each of us took primary ownership of one of the topics, and we met monthly to review others' session plans and instructor guides.

We employed the pedagogical method of case-based learning[7] with hands-on pulmonary devices to help the learner link basic science theory with practice. Cases used in each session are based on clinical situations frequently encountered in the ICU and pulmonary clinics. Each teaching session was designed with the premise that no computerized visual aid would be used and a pulmonary device would be incorporated into the session. Learners get to manipulate the device and thereby understand in a tangible way the effect the operator has on the results collected or on the treatment received by the patient.

At our institution, one session is typically offered each month to trainees as part of the internal medicine residency program's daily noon conference series. The target audience for this curriculum consists of internal medicine residents, medical students, pulmonary and critical care fellows, and internal medicine attending physicians. The novelty of this curriculum is its hands-on and problem-based approach. Even amongst pulmonary and critical care medicine fellows, this may be the first time a trainee has actually manipulated a device on his or her own.

Methods

At our institution, the sessions are taught by attending physicians in pulmonary and/or critical care and/or sleep medicine. Sessions are designed for a maximum of 15 learners to maximize the hands-on, interactive format. Facilitators follow the instructor guide for each topic. Each session incorporates basic didactics with case-based problem solving that requires learners to either manipulate the device or interpret raw data from it. During the oxygen delivery, positive airway pressure (PAP), and spirometry devices sessions, learners experience the device as a patient would, by fitting themselves with an oxygen or PAP mask or performing their own spirometry. During the tracheostomy and thoracostomy sessions, learners handle tracheostomy tubes, thoracostomy tubes, and thoracostomy drainage devices. The sessions may be taught in isolation or in any order.

This curriculum requires the presence of faculty facilitators with clinical expertise in using and prescribing the pulmonary devices covered by these sessions. The curriculum was developed by pulmonary, critical care, and sleep medicine physicians; however, other facilitators could potentially include otolaryngologists, thoracic or general surgeons, and respiratory therapists. We found it successful to offer

the pulmonary hands-on curriculum several times a year as part of the existing internal medicine noon conference structure.

Due to the unique format (and limited time) of the sessions, we recommend identifying a core group of two to five committed facilitators who can familiarize themselves with the curriculum beforehand, feel comfortable leading an interactive teaching session, and engage in ongoing quality improvement. Leading this type of hands-on session takes enthusiasm, concentration, and time-management skills. Because learners frequently asked follow-up questions, we found that it could take facilitators several trials to balance efficiency and coverage of all the content. We also found that the facilitators who could attend others' sessions provided invaluable feedback for ongoing curriculum improvement.

It is not necessary to implement the curriculum in its entirety. Each session can be taught entirely independent of the others, and therefore, it is possible to pick any session for implementation or to start with one or two and then add others as the facilitators gain familiarity with the material and confidence with the teaching style suggested.

Featured in this submission is all the documentation necessary to implement this pulmonary hands-on curriculum. This includes an instructor guide for each of the sessions. Each instructor guide starts with an equipment list and outlines the steps for the teaching session, including our recommendations for diagrams, questions to the group of learners, and answers. At our institution, we keep the equipment for each of these sessions in boxes so that it does not have to be reassembled each time.

For each session, the instructor needs to assemble all of the needed equipment and read the guide in advance. At the time of the teaching session, the instructor follows the instructions in the session's instructor guide. The guides include questions to ask the participants and instructions on when to hand the devices to the participants and which diagrams to draw.

Session 1: Oxygen Delivery Devices
Appendix A is the instructor guide for the oxygen delivery devices session. As listed on the first page of this document, the following equipment is needed for this session:

- Nasal cannula.
- Mustache cannula and pendant cannula.
- Face tent.
- Simple face mask.
- Reservoir mask.
- Venturi mask.
- Misti-Ox device.
- High-flow nasal cannula.
- High-flow generator.
- Whiteboard, chalkboard, or large paper flip chart.
- Markers or chalk.

Session 2: Spirometry
Appendix B is the instructor guide for the spirometry session, which includes the challenge for this session. It involves three flow-volume loops with their volume-time curves, forced expiratory volume (FEV1), forced vital capacity (FVC), and FEV1/FVC ratios. They are three attempts at a forced spirometric manuever, performed by one individual in one sitting. They provide an example of technically inadequate spirometry to be handed to the learners at the beginning of the session for them to attempt to interpret. As the instructor leads the learners through the session, the inadequacy of this spirometry becomes apparent, and at the end of the session, the instructor should facilitate the learners' interpretion of this challenge. As listed on the first page of this instructor guide, the following equipment is needed for this

session:

- Portable spirometers (we used four ndd EasyOne spirometers).
- Spirettes (mouthpieces), at least one for each spirometer, with at least one altered to simulate obstruction (see detailed instructions and photo in the guide).
- Whiteboard, chalkboard, or large paper flip chart.
- Markers or chalk in multiple colors (at least three colors).
- Copies of the challenge for all participants.

Session 3: PAP Devices
Appendix C is the instructor guide for the PAP devices session. As listed on the first page of this instructor guide, the following equipment is needed for this session:

- Whiteboard, chalkboard, or large paper flip chart.
- Markers or chalk in multiple colors (at least three colors).
- Stopwatch.
- Three PAP devices:
  - CPAP 7 cm.
  - Bilevel 12/6 cm.
  - Bilevel 10/5 cm, rate 15.
- Scrap paper.
- Three PAP downloads (Appendix D contains the downloads without hints or answers, Appendix E contains the downloads with hints for the participants, and Appendix F contains the downloads with the answers to the questions):
  - Elevated apnea-hypopnea index (AHI) with obstructive events.
  - Elevated AHI with central events.
  - Elevated AHI with mask leak.

Session 4: Tracheostomy Tubes
Appendix G is the instructor guide for the tracheostomy tubes session. As listed on the first page of this instructor guide, the following equipment is needed for this session:

- Tracheostomy tubes:
  - Cuffed.
  - Noncuffed.
  - Fenestrated.
  - TTS (optional).
  - XLT (optional).
  - Tracheal button (optional).
- Passy-Muir valve and booklet.
- Pictures of trachea-innominate fistulae and Utley's maneuver.
- Whiteboard.
- Three different-colored markers.

Appendix G contains images of the tracheostomy equipment mentioned. We recommend gathering as many pieces of the tracheostomy equipment as possible so that the participants can handle them. However, some of the items may not be stocked at your institution, and if so, the images from the document should suffice. Appendix H is a series of questions referred to in the instructor guide as the challenge for the session. These questions are intended to be handed out at the beginning of the teaching session (perhaps while waiting for all the participants to arrive) to stimulate interest. They could also be interspersed during the session by the facilitator. The questions and their answers are also included at the end of the instructor guide. These questions are, however, optional for this session.

Session 5: Thoracostomy Tubes

Appendix I is the instructor guide for the thoracostomy tubes session. As listed on the first page of this instructor guide, the following equipment is needed for this session:

- Two Atrium “dry” collection systems.
- Chest tube catheters: 14F pigtail with and without lock and 36F large-bore.
- Insertion kits and supplies: Wayne pneumothorax kit and Kelly clamps.
- Emergent needle decompression: 14G needle and catheter and one-way valve of syringe, tubing, and plastic cup.
- Whiteboard, chalkboard, or large paper flip chart.
- Markers or chalk in multiple colors (at least three colors).
- Copies of the challenge for all participants (a short scenario included in the instructor guide that could be written on the board, handed out on slips of paper, or just discussed verbally).

Results

The curriculum was implemented in the fall of 2015. At least 11 formal sessions have been held, facilitated by five of us and one additional facilitator. One of us has facilitated three of the sessions (thoracostomy, spirometry, and oxygen delivery devices), another has facilitated two of the sessions (spirometry and oxygen delivery devices), and one nonauthor, an internal medicine and sleep physician, has facilitated the PAP session. Additional formal sessions have been held without the use of the surveys, and informal sessions on these topics have also been held. A number of us, when attending on the medical ICU or pulmonary consult service, use the equipment and instructor guides to lead hands-on sessions on these topics for our teams (consisting of residents, medical students, and pulmonary/critical care fellows).

Immediately prior to 10 of the formal sessions, learners were given a survey including questions to answer prior to the teaching session (the presession survey) and questions to answer after completion of the session (the postsession survey). The presession surveys featured questions on level of training, training specialty, and prior formal teaching on the topic; one question asked the learners to rate their understanding of the subject matter, and two assessed subject knowledge. The postsession surveys included one question asking the learners to rate their understanding of the subject matter, two questions assessing subject knowledge, a question on the learners’ perceived value of the hands-on teaching modality, and an area for comments. These surveys have been included as Appendices J, K, L, M, and N.

A total of 52 learners anonymously completed the pre- and postsession surveys. More learners participated in the sessions than returned surveys due to time constraints. The learners were medical students in their third and fourth years, interns in categorical and preliminary internal medicine tracks, internal medicine residents, and fellows in pulmonary and critical care medicine. For some topics, the mean scores on the pre- and postsession knowledge questions showed improvement: spirometry, 10% to 67%, and PAP devices, 50% to 78%. For other topics, the mean scores on the pre- and postsession knowledge questions showed very little change: thoracostomy tubes, 78% to 80%, and oxygen delivery devices, 44% to 50%. The mean perceived level of subject understanding (on a 5-point Likert scale) improved from poor-neutral to neutral-good. Learners indicated overwhelmingly that they had never before received formal teaching on these devices. The surveys also indicated that participants felt the hands-on style of teaching was more effective than a conventional lecture: The sessions scored a mean of 4.5 on a 5-point Likert scale, indicating the teaching style was somewhat-very much more effective.

Example comments included the following:

- “Super awesome!”
- “Interesting and enjoyable!”
- “Hands-on is good.”

- "Thank you for bringing examples."
- "Thank you for bringing props."
- "I liked the demonstration of spirometry."

Discussion

The goal of this curriculum is to provide a hands-on, practical experience for medical trainees in pulmonary equipment commonly encountered in the pulmonary and ICU settings using curriculum documents that can be easily implemented by any facilitator with sufficient familiarity with the device under discussion. In terms of increasing exposure and understanding, we found that that these sessions were the first formal training about the devices most participants had received. For the spirometry and PAP device sessions, postsession surveys showed improvement in understanding. For the sessions on thoracostomy and oxygen delivery devices, the data were not clear as to whether understanding had improved. In terms of creating interactive sessions, we were successful, and participants reported that they appreciated the opportunity to handle the devices. In terms of creating a curriculum that can be used by multiple facilitators, our experience suggests that these documents are sufficient to achieve this.

However, there are limitations to this evaluation. First, the survey completion rate was low. The low response rate on the surveys was related to the fact that participants (mostly medicine residents) did not arrive promptly for noon conferences and often left early. The low response rate makes it hard to judge if the curriculum achieved the goal of increasing learners' knowledge about pulmonary devices. However, the fact that most learners reported never having received formal teaching on the devices suggests that the implementation of this curriculum likely has at least increased awareness about these devices.

Next, we made no formal evaluation of the facilitators' experience of leading sessions. However, those of us who facilitated more than one session and the nonauthor facilitator reported that the curriculum documents were easy to use after a thorough review and preparatory run-through. The fact that a number of us use the curriculum (and assembled equipment) to provide informal teaching sessions indicates that the curriculum is a useful resource. We did find that successful implementation of the curriculum requires working examples of the pulmonary devices themselves and faculty highly familiar with their clinical use. While the curriculum was developed at a tertiary care academic center, we focused on devices that should be present in most medical settings. Each session is a stand-alone learning experience, and therefore, the curriculum can be modified to the needs of a particular institution.

Finally, in terms of session content evaluation, while overall scores were higher on the post- than the presession knowledge questions (mean scores increased from 37% to 68%), we were surprised to find that in some subject areas, there was no apparent improvement in content knowledge. It is possible that learners did not learn the necessary information from these 1-hour sessions to score better on the post- than the presession questions. Indeed, given the low level of perceived content knowledge prior to the session, perhaps these sessions should be viewed as topic introductions, which can facilitate further learning on the subject in the future. On the other hand, review of pertinent questions (knowledge questions with mean scores of 50% on both pre- and postsession surveys) suggested that our question design was at least partly to blame for this result. Furthermore, a two-question survey is likely insufficient to really assess what a learner has acquired from the sessions. Although we reviewed the survey questions together, we did not pilot them on learners prior to using them in the curriculum.

The instructor guides included in this submission represent revised guides, based on our experience of running the sessions, the feedback from participants and coauthors who observed teaching sessions, and the survey results, after running the curriculum for about 18 months. We have stopped using the pre- and

postsession surveys and have incorporated some of the more useful questions into the instructor guides. We felt that these surveys were not a good use of time with the learners. If we were to continue using the surveys, the knowledge questions for some of the topics (oxygen delivery devices and thoracostomy tubes) need reworking. We have therefore not mentioned the use of the surveys in the Methods section or in the instructor guides for the sessions; however, users of this curriculum may choose to use some or all of these surveys.

While designed for medical residents and students, this curriculum could be expanded to other health professionals and students who frequently encounter patients using these devices. The curriculum provides basic knowledge of these devices relevant to any provider prescribing or managing their use. In the case of PAP and spirometry, the curriculum also provides trainees with a glimpse of these devices from the patient's perspective.

Our curriculum offers a novel and unique opportunity to engage students in practical, hands-on use of pulmonary equipment. There is significant potential to replicate and expand this type of hands-on curriculum to other health professionals, including students, nurses, and practicing physicians, who commonly encounter these devices in their clinical practice. We recommend that future replications and implementations include a more systematic evaluation of participants' expertise and change in their clinical practice as a result of participation.

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