Adaptation of airline crew resource management principles to dentistry

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The public's view of a health care facility typically is one of a well-controlled and safe environment. Like others in health care, dental care providers strive to provide quality care while doing no harm. Occasionally, however, patients may be harmed as a result of technical and human factors. Error in treatment often results from issues not central to the actual procedure being performed. While practitioners have developed their own strategies to mitigate errors, there has been little effort to formulate systematic solutions.

By contrast, the airline industry has had decades of experience in addressing similar issues. Early and dramatic accidents have led to the implementation of systems designed specifically to address adverse human factors in a systematic fashion. The airline industry has adopted crew resource management (CRM) as a foundation for addressing the human aspects of flight. Improved safety and efficiency records are testimony to these successful methods, which have been adapted by other industries, including hospitals.

The results of six government-sponsored studies suggest that training in decision making reduces...
errors, and the studies demonstrated improvements in safety ranging between 8 and 46 percent ($P = .05$).\textsuperscript{1} Investigators in another study of six large corporations and military entities that adopted CRM strategies reported accident reduction rates of between 36 and 81 percent ($P = .02$).\textsuperscript{4} Recognizing the potential of CRM, the medical profession has begun to implement CRM strategies\textsuperscript{5} to address error.\textsuperscript{6} The dental profession, however, has yet to adopt CRM strategies systematically.

The purpose of this article is to describe the fundamentals of CRM that are applicable to dentistry and suggest how dental professionals can translate these principles into practice. We offer a dental checklist as a first step toward incorporating CRM principles.

**CREW RESOURCE MANAGEMENT**

CRM has been defined as making use of all available resources—information, equipment and people—to achieve safe and efficient flight operations.\textsuperscript{7} Flying an airplane and practicing dentistry are highly technical endeavors that take years of training and practice to achieve high levels of competence. Both pilots and dentists perform complex procedures that require expertise and team participation. Continuous improvements in areas such as workplace design and materials combined with increasing complexity are hallmarks of both the airline industry and dentistry, in which information, equipment and people are integral to successful flight and clinical outcomes.

The airline industry started focusing on CRM three decades ago after pilots and psychologists recognized that human error was the source of most accidents.\textsuperscript{8,9} The results of early analyses demonstrated consistently that a chain of often minor individual mistakes led to catastrophic events. Error rates cannot be reduced by technology alone. Investigators conducted accident analyses, the results of which revealed that responsibility could be traced to all members of the team, and blame often could not be attributed to a single person.\textsuperscript{8,10} These findings are in striking contrast to commonly held beliefs in the health care industry, which, until recently, has singled out individual accountability and addressed technical errors by modifying or enhancing isolated individual skills.\textsuperscript{11}

CRM relies on group interaction to process information, make use of proper equipment and engage all people involved. To accomplish this, the team leader listens to team members and solicits their feedback in an environment that encourages people to offer their observations. However, the team leader ultimately is responsible and makes the final decisions. Mazzocco and colleagues\textsuperscript{12} reported that teamwork reduced mortality and major complications in surgical patients.

The flight deck and the dental office bear many similarities. Both are composed of a few people with significant responsibilities. Increasingly, both have access to outside support. For example, an airline captain relies on all onboard crew members, company dispatchers and air traffic control personnel to prepare for and safely accomplish a flight. Pilots are trained repeatedly to incorporate out-of-cockpit resources in their decision-making process. On the other hand, dentists have not yet developed a systematic approach to incorporating essential elements of CRM. This is surprising in that oral health care providers have a wealth of out-of-office resources (such as specialists, physicians and other health care professionals; dental societies and associations; vendors; continuing education courses; and Internet resources) they can access easily by using a CRM framework to provide optimal care to patients.

**SAFETY AND RISK**

The dictionary defines safety as “the condition of being safe from undergoing or causing hurt, injury, or loss.”\textsuperscript{13} The Federal Aviation Administration (FAA) has defined system safety as “the application of special technical and managerial skills in a systematic, forward-looking manner to identify and control hazards throughout the life cycle of a project, program, or activity.”\textsuperscript{14}

Consequently, any discussion of safety and risk requires consideration of forward-looking techniques and strategies. Risk analysis is a tool to interpret data\textsuperscript{15} that combines technical information (for example, issues related to bonding of fifth-generation versus seventh-generation resin-based composite) and human aspects (for example, a procedural error during placement of a resin-based composite restoration). Human error during placement does not necessarily lead to an unsuccessful final restoration. If both human and

technical aspects of composite placement have been controlled consistently, the likelihood is increased that the restoration will provide long-term service. A detailed, methodical risk analysis of past procedures ensures that future procedures, such as placement of resin-based composites, will be increasingly safe.

**EFFICIENCY**

As noted in the definition of CRM, safety and efficiency are linked and are an integral part of the process. Both the pilot and dentist must execute tasks at a rapid pace to be efficient. One way to maximize safety is to avoid risk and take on only simple tasks. Flying a plane in daylight and clear weather with no wind and no mountains or treating one patient per day would lower risks simply by reducing the number of exposures to potential threats. Limiting behavior in this way, however, is not a practical solution to improve safety. For an airline pilot or a dentist to succeed, some exposure to threats is inevitable.

One goal of CRM is to increase efficiency, which can reduce error through repetition (that is, an oral surgeon likely is more efficient than a general practitioner in performing third molar extractions). It is somewhat paradoxical, then, that increased repetition (which achieves efficiency) can increase risk simply by increasing the number of exposures. The more often a procedure is performed, the more likely a statistically improbable event will occur. Therefore, efficiency increases safety but also increases the chance of error. CRM techniques, when incorporated properly, should increase efficiency and safety through better management of the human element, while reducing the time needed to perform a procedure, as well as minimizing costs and loss of goodwill associated with error.

**SITUATIONAL AWARENESS**

To an untrained observer, virtually any airplane flight deck or any dental procedure appears complex. However, to the trained professional, each of these domains is replete with nuances that often are obvious to those with similar training and experience. If a trained professional were to observe another trained professional performing a procedure, it is likely that he or she would identify details that are unappreciated by the untrained eye. This concept can be described by the term “situational awareness” (SA), which Endsley defined as the “perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.”

Jones and Endsley conducted a study in which they identified the lack of SA as a significant source of error in aviation. When pilots are disoriented or gradually overwhelmed by the need to perform a number of tasks, their SA decreases. As a result, the margin of safety often is reduced and errors may compound to the point at which the pilots may lose control of the airplane. This may result in a tragic outcome (Figure 1). Unfortunately, loss of SA can happen to any pilot regardless of experience. A tragic accident occurred in 1977 in Tenerife, Canary Islands, when two 747 airplanes collided in the fog, resulting in significant loss of life. The captain of the plane taking off was among that airline’s most experienced.

Similarly, a catastrophic airline crash occurred in 1972 in the Florida Everglades when three experienced crew members on the flight deck diverted their attention while attempting to change a light bulb used to indicate the position of the landing gear. No one noticed that the autopilot was engaged in the wrong mode, and the airplane slowly descended until it crashed. These accidents illustrate a common theme: a loss of SA.

Examples in dentistry of a loss of SA include losing count of the number of anesthetic carpules administered during a procedure and allowing a material to set during an impression or cementation procedure owing to a delay resulting from doing “one last little thing.” A simple and common example of loss of SA is missing an exit on the highway because of a distraction. This loss of SA has minimal consequences. If the car is low on fuel, however, and the next exit is 10 miles ahead, the consequences could be more significant.

**ERROR**

The mitigation of error is the fundamental building block on which all CRM principles are based. Although error is a complex subject, we
will discuss two types of errors—those of omission and those of commission. Omission, or inaction, may constitute an error. In contrast, errors of commission are acts performed improperly or in the wrong sequence or timeframe. Each type of error can be divided further into actions that are too great or small in scope or are in the wrong direction. Errors in all aspects of health care are well-known. Because human error is inevitable, it is impossible to practice dentistry without making mistakes. Figure 2 demonstrates the possible error pathways during treatment. However, the simple process of discussing and reviewing error in detail increases our understanding of what constitutes an error. This ultimately can lead to improvements in patient safety and practice efficiency.

**THREAT**

The goal of safety is to avoid error or mitigate negative consequences of error. Phrases such as “I should have,” “if only I had” or “next time I will” are retrospective responses to one’s recognition of having made an error. Error is best mitigated in a prospective manner. The practice of CRM addresses potential errors prospectively by considering them as threats. A threat is anything that increases the complexity of a situation.

Although the concept of a threat is intuitive, threats range from the mundane (such as forgetting to look at a radiograph) to the spectacular (such as a broken root tip during an extraction). Fatigue is a known threat because people do not perform optimally when tired. In a cross-sectional survey, Sexton and colleagues found that pilots were less likely than surgeons to deny the effects of fatigue on performance (26 versus 70 percent, respectively). Why do pilots recognize that a natural event such as fatigue is a threat more than do surgeons? The answer lies in training and culture.

Pilots follow specific FAA rules to mitigate the effects of fatigue on performance. Similarly, increasing restrictions have been placed on the number of hours for which medical residents can be on call in accredited graduate medical education programs in recognition of the potential adverse effects of fatigue on safety. The rules regarding how long medical residents can be on call and awake represent efforts to recognize just how long a physician can remain functionally alert.

Though no similar formal guidelines exist for dentists, oral health care professionals often tacitly recognize fatigue as a threat (for example, by preferring to perform complex procedures early in the day when they are fresh and alert). They may...
avoid complex procedures after lunch, when postprandial fatigue occurs. These practice habits, although not recognized overtly as such, assist the practitioner in maintaining SA. Threats occurring during a loss of SA may lead to errors of potentially greater magnitude than those that might occur when SA is optimal. This type of practice modification illustrates the use of CRM techniques to reduce error.

**THREAT AND ERROR MANAGEMENT**

Threat and error management (TEM) has evolved as an aspect of CRM to enable participants to identify and trap errors early to reduce unexpected outcomes. Although eliminating error is not realistic, it is best to mitigate risk at its earliest stages. For example, poor weather increases the threat of an airplane’s crossing an active runway while taxiing. The captain and first officer practice TEM by verbalizing the expected taxi route, keeping the map visible at all times for reference, taxiing slowly and discussing expected landmarks as they proceed. They perform required tasks in a “heads-down” position and review the checklist only when stopped. By maintaining SA, pilots have decreased the chance of an error’s occurring.

In medicine, physicians can envision similar complications when performing an invasive procedure in a patient who has a complex health history (for example, uncontrolled diabetes, smoking and congestive heart failure). A brief TEM-based discussion among all team members during which they review patient-specific issues immediately before the procedure can reduce the chance of a negative outcome. Furthermore, this discussion fosters CRM and team participation by providing an opportunity for open dialogue.

An example of TEM in dentistry is when dentists discuss with team members the effect of a complex extraction on specific team members’ roles, on the schedule or both. A morning office huddle is another example of TEM. The common purpose of TEM in aviation, medicine and dentistry is to increase SA so that safety issues (threats) are identified and addressed early, thereby preventing an error or enabling the team to recover easily from an error and move on.

Figure 3 illustrates how early identification of a threat results in early resolution, with reduced negative consequences. The best outcomes result consistently when SA is reestablished. For example, when a dentist excavates tooth decay with the use of a rubber dam and the team is prepared for a pulp exposure and none occurs, the outcome likely is satisfactory. However, when he or she excavates tooth decay without the use of a rubber dam and an exposure occurs for which the team is not prepared, the outcome may be less than satisfactory. By planning for an exposure, the dentist can reduce the threat of a poor outcome.

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Taken a step further, if the patient is treated without the use of a rubber dam and has diabetes (a threat) and the dentist has not planned for this adequately in the pretreatment patient evaluation (another threat), the patient might experience syncope in conjunction with an exposed pulp; this could result in a poorer prognosis for the tooth owing to poor TEM. A possible irreversible outcome would be that the tooth ultimately needs to be extracted. This example demonstrates that a prognosis for a tooth may depend on external factors. Admittedly, the above situation is rare, yet dentists perform millions of caries excavations each year. Undoubtedly, a certain percentage of these result in an untoward outcome as a result of operator error. Supporting data from the airline industry and from hospital operating departments suggest that TEM techniques, when used properly, can reduce the error rate resulting from dental procedures.

**HEALTH CARE CHECKLIST**

In an effort to help professionals maintain SA and practice TEM routinely, organizations have advo-
cated the use of safety checklists. Adapting an idea from the airline industry, the World Health Organization (WHO) developed a surgical checklist to be incorporated into the hospital surgical setting. Its purpose is to ensure a baseline safety. In medical settings, use of this checklist has been shown to improve safety, with postoperative complications and death rates reduced by as much as 36 percent.

A safety checklist is founded on the principle that human error is inevitable. It helps people focus on the tasks at hand, reflects the fact that people lose SA over time and experience difficulty maintaining focus, and helps clinicians establish guidelines for care. Reading a checklist aloud allows for a standardized set of prescribed and choreographed communications among team members that takes little time to perform. Each team member has a role. Any break in the chain will cause all team members to take notice and correct the situation. Any member of the team can be empowered to use a checklist.

Hospital operating departments have adopted a time-out procedure in which one person is responsible for requesting that all parties stop what they are doing and confirm that they have addressed the various items on the checklist. Confirming the use of prophylactic antibiotics and that the proper instruments are in place are examples of ensuring that tasks have been performed before the initiation of procedures. Taking a moment to discuss a plan of action is an example of performing something on the checklist. A direct challenge and response to each item, preferably orally, allows all involved an opportunity to ensure that checklist items are completed. This ensures that SA remains high, whether the team is treating the first patient of the day or the last. The team’s consistent use of a checklist for each patient and procedure is a positive step toward reducing errors and increasing efficiency. This is much like the pilot’s performing safety checks during each phase of flight, because time is not wasted recovering from missed items covered by the checklist.

**DENTAL CHECKLIST**

Our proposed dental checklist (Figure 4) is based on our experiences, on the WHO surgical checklist and on the 2007 American Dental Association guide for dental records. We positioned items in a sequence that facilitates identification of potential threats at the earliest point to mitigate negative consequences. It is beyond the scope of this report to provide procedure-specific checklists, although developing these would be a logical extension of CRM theory as applied to dentistry. The items on our proposed checklist are general in nature, allowing each practitioner to customize them to meet the specific needs of his or her practice. Dental practices should use the checklist for each patient encounter. The outpatient dental visit is divided into five phases, as described below. Each phase contains items that are appropriate for a generic timeline. The dentist or a team member should read aloud each challenge and confirm its completion orally, preferably by using a team approach. The clinician or a team member then performs remaining tasks as appropriate. After finishing each phase of the checklist, the designated team member should state, for example, “appointment review checklist complete.” This choreographed dialogue is similar to that which occurs on airplane flight decks for each and every commercial flight.

**Appointment review.** This phase, equivalent to an airplane’s preflight, encompasses items that need to be accomplished before initiating a planned dental procedure. Although each item may or may not involve an action, the intent of this phase is to lay a foundation on which all future action is built (such as review the patient’s dental and medical histories, screen for oral cancer, confirm the availability of equipment and materials).

**Before procedure.** This phase, equivalent to an airplane’s takeoff, is the first time that the clinician actually will do something that could have an irreversible consequence (for example, administering anesthetic, removing gross caries to determine a definitive treatment plan). Verbalization of the plan allows for increased SA and threat recognition, which are particularly important if the clinician needs to deviate from the plan unexpectedly.

**Procedure.** During this phase, which is equivalent to an airplane at cruise, the clinician, with the assistance of the dental team, performs the bulk of the required work (for example, after removing gross caries, proceeding with a course of action such as restorative treatment, temporization, root canal therapy or extraction).
Dental checklist for outpatient dental visits.*

<table>
<thead>
<tr>
<th>CHALLENGE</th>
<th>RESPONSE</th>
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<tbody>
<tr>
<td>Appointment Review</td>
<td></td>
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<tr>
<td>Verbalize medical history; medications current, updated, reviewed</td>
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<tr>
<td>Verbalize premedication status</td>
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<tr>
<td>Review allergies (medications, materials)</td>
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<tr>
<td>Update dental history (such as periodontal examination, oral cancer screening, temporomandibular joint)</td>
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<td>Review notes from other health care providers, including specialists</td>
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<tr>
<td>Review treatment plan documentation</td>
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<tr>
<td>Verbalize procedure; confirm if informed consent required</td>
<td>![ ]</td>
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<tr>
<td>Verbalize that radiographs and/or study models are available</td>
<td>![ ]</td>
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<tr>
<td>Verbalize that all equipment and materials are available</td>
<td>![ ]</td>
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<tr>
<td>Verbalize the level of assistance required</td>
<td>![ ]</td>
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<tr>
<td>Review special instructions, needs for today's procedure</td>
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<tr>
<td>Before Procedure</td>
<td></td>
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<tr>
<td>Verbalize anesthetic method, location, expected amount</td>
<td>![ ]</td>
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<tr>
<td>Verbalize critical steps in sequence</td>
<td>![ ]</td>
</tr>
<tr>
<td>Verbalize potential deviations from treatment plan</td>
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</tr>
<tr>
<td>Procedure</td>
<td></td>
</tr>
<tr>
<td>Perform preliminary procedure (such as caries removal, gross debridement)</td>
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<tr>
<td>Determine final procedure and inform patient</td>
<td>![ ]</td>
</tr>
<tr>
<td>Verbalize new critical steps in sequence</td>
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<tr>
<td>Before Dismissal</td>
<td></td>
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<tr>
<td>Review with patient the treatment performed</td>
<td>![ ]</td>
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<tr>
<td>Review with patient postoperative instructions and care</td>
<td>![ ]</td>
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<tr>
<td>Prescribe medications (verbalize that no contraindications exist)</td>
<td>![ ]</td>
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<tr>
<td>Complete referral forms</td>
<td>![ ]</td>
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<tr>
<td>Inform patient of next step</td>
<td>![ ]</td>
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<tr>
<td>After Dismissal</td>
<td></td>
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<tr>
<td>Review unexpected events</td>
<td>![ ]</td>
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<tr>
<td>Inform team members of necessary follow-up items</td>
<td>![ ]</td>
</tr>
<tr>
<td>Review any equipment problems</td>
<td>![ ]</td>
</tr>
<tr>
<td>Complete laboratory prescriptions</td>
<td>![ ]</td>
</tr>
<tr>
<td>Record legible notes in patient's dental record</td>
<td>![ ]</td>
</tr>
</tbody>
</table>

* Sources: World Health Organization and American Dental Association Council on Dental Practice and Division of Legal Affairs.

Figure 4. Five-phase dental checklist.
Before dismissal. This phase, equivalent to an airplane’s landing, is when the clinician or an assigned team member completes all items requiring the patient’s presence (for example, providing postoperative instructions, confirming the use of proper analgesics).

After dismissal. During this phase, which is equivalent to an airplane’s taxing to the gate after a flight, the team leader ensures that all details of the patient’s visit have been finalized (such as writing progress notes, preparing laboratory prescriptions, discussing the case with a dental specialist or physician).

In aviation, checklists are specific to different airplanes and phases of flight. The dental office should adopt its checklist to accommodate specific needs. The active use of a checklist is valuable for general dentists as well as specialists, and it is applicable to all dental procedures, ranging from the most common (such as routine caries removal) to the most complex. We should note that airlines modify checklists regularly, even for airplanes that have been in service for many years. Checklists evolve to incorporate new information or technological enhancements. In addition, checklists for identical airplanes differ from airline to airline, yet they accomplish the same goal. Similarly, dental professionals should recognize that although the specific checklists will evolve continuously to accommodate changes, it is the consistent use of the checklist that remains constant.

In this report, we introduced the concept of CRM as it relates to dentistry. A clear limitation of this work is the lack of specific peer-reviewed studies demonstrating that CRM is effective in dentistry. However, the fundamental concepts and principles of CRM are evident in the dental literature, absent the specific and direct terminology. For example, several studies in different fields of dentistry used checklists. In a study that had clear CRM overtones, Haak and colleagues demonstrated that a course in communications improved dental students’ competence when they interacted with their patients. Good communication is fundamental to CRM.

In addition, Le and colleagues conducted a study in which they determined that 50 percent of third- and fourth-year dental students were unable to operate emergency oxygen equipment satisfactorily. Although it was clear that students possessed the didactic knowledge, they were unable to perform the procedures adequately in a simulated setting. The authors identified the problems as being driven by human factors and, consequently, used TEM techniques (periodic simulation exercises) to address the students’ deficiencies.

However, there are clear limitations to incorporating CRM—as designed for the airline flight deck—into dentistry. For example, airline flying often involves multiple crew changes, which result in frequent personnel turnover. Dentists, on the other hand, often work in the same setting for extended periods, with infrequent personnel changes. In addition, two equally skilled professionals working as a team are on the airplane’s flight deck, while a single practitioner typically performs dental procedures. Nevertheless, the concept of CRM provides opportunities for all members of the health care team to participate in the delivery of more effective and safe patient care.

Conclusions

Our purpose has been to describe aspects of CRM and provide a checklist applicable to dentistry. There is substantive value in borrowing CRM concepts from the airline industry, as incorporated by the medical profession and by hospitals. A checklist is an organizational tool that empowers each member of the dental team. It helps people organize their thoughts, identify errors and increase SA. SA is increased by using a CRM team approach to practicing effective TEM. Optimal TEM incorporates the use of standard operating procedures, as reflected by the items on the checklist. We believe that the dental profession would be well served by implementing CRM strategies to reduce errors. We propose that practitioners begin by incorporating this dental checklist or a modified version into their practices and using it on a consistent basis.

We hope this article fosters a discussion among clinicians regarding ways in which they can incorporate CRM into their practices. We encourage people to tailor the checklist to fit their specific needs. In addition, we propose that readers pause for a moment to reflect on this question: If you needed to undergo a dental procedure, would you feel more comfortable if the dental team practiced the fundamentals of CRM by using a challenge-and-response checklist?

Disclosure: None of the authors reported any disclosures.

This project was supported in part by funds from the University of Michigan’s Scholars Program in Dental Leadership (UM-SPDL).

The authors extend their sincere thanks to Harold Crosthwaite, DDS, MS; Josef Kolling, DDS, MS; Fredrick Lurie, DDS; Ross Nelson; Stephanie Nunez; Debra A. Pinals, MD; and David J. Pinsky, MD.