I-AIM

A Novel Model for Teaching and Performing Focused Sonography

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This project was designed to use existing evidence in education and clinical quality improvement to design an educational and clinical model specific for physician-performed focused sonography. The I-AIM model (indication, acquisition, interpretation, and medical decision making) was created to serve as both a mnemonic and checklist. The model follows a stepwise logic for performing focused sonographic examinations and contains detailed subcomponent listings that cover specific areas to improve use and performance. Although validation and reliability studies will be required before implementation, the I-AIM model represents the first effort to standardize and improve clinical and educational focused-sonography.

Key Words—algorithm; education; pedagogy; sonography; teaching

Physician-performed focused sonography is an emerging field within medicine and has potential for a range of diagnostic and therapeutic indications.[1] In 1999, the American Medical Association approved policy H-230.960, asserting that physician-performed focused sonographic examinations should be performed if within the scope of the physician's specialty.[2] American Medical Association policy H-385.934 later stated that physician-performed focused sonographic examinations are billable procedures in patient care.[3] Although there have been few efforts by medical specialties to formally define the scope of practice for physicians within their field, physician training programs have undertaken substantial efforts to implement ultrasound education programs.[4–13]

Ultrasound education programs for physicians are currently designed to develop knowledge and skills in specialty-specific applications of focused sonography. Unlike comprehensive sonography, typically performed by either a sonographer or radiologist and assessing multiple clinical questions, focused sonography generally answers a focused clinical question.[4–6] Early physician training programs in focused sonography have been tested across the spectrum of medical school, residency, and fellow levels.[4–13] For example, focused transthoracic echocardiography, which seeks to determine the presence of a pericardial effusion and estimate cardiac contractility, was shown to be feasible in a training program for early medical student, resident, fellow, and attending cohorts.[14–16] Although the discussion of where focused sonography training is best suited within the physician training paradigm persists, the main issue re-

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Abbreviations
ATLS, Advanced Trauma and Life Support; FAST, focused assessment with sonography for trauma; I-AIM, indication, acquisition, interpretation, and medical decision making

mains development of a reliable teaching and clinical practice model for physicians. The purpose of this article is to describe the evidence for and preliminary development of an educational and clinical practice model at The Ohio State University College of Medicine for focused sonographic examinations.

Concept

A multitude of educational and clinical practice models have been developed to improve knowledge retention, data use, and error and procedural complication reduction. Mnemonic devices are examples of a well-established educational model that improves knowledge retention and future clinical use.[17,18] Although mnemonic devices can be structured with either a random or specific order, the use of an instructional order has been shown to have the greatest effect size for clinical procedures.[19] For example, the mnemonic NAVEL (nerve, artery, vein, empty space, and lymphatics) for remembering the order of femoral triangle contents is ordered from lateral to medial, thereby serving as a method to remember both the contents and order of the femoral triangle. Similarly, checklist devices are clinical practice models with a growing acceptance for error and complication reduction. Recently, checklists have been used to reduce catheter-associated infections in intensive care units and reduce errors and operative morbidity in surgical settings.[20–23]

The I-AIM model is designed as both a structured mnemonic and checklist for focused sonography: (1) indication, (2) acquisition, (3) interpretation, and (4) medical decision making. A detailed outline of the I-AIM model with headings, components, and subcomponents is listed in Figure 1. A general outline of the I-AIM model is described below, followed by a clinical example.

Indications

The most important step in diagnostic imaging is determining the medical necessity and comparing the clinical risk versus benefit. The scope of practice is defined by the physician's professional college such as the American College of Emergency Physicians.[24] Additionally, for every examination and indication there exists varying evidence and a demonstrated or potential clinical benefit. Evidence-based practices with large effect sizes have level I or II data, which definitively support their clinical use, such as focused assessment with sonography for trauma (FAST) for the evaluation of trauma patients with blunt abdominothoracic trauma and hypotension of unknown etiology. Mechanism-based evidence uses novel practices that lack definitive evidence, although their use within narrow clinical practices is reasonable based on existing knowledge. An example of this process is transtracheal sonography as a means to determine placement of an endotracheal tube.

Acquisition of Images

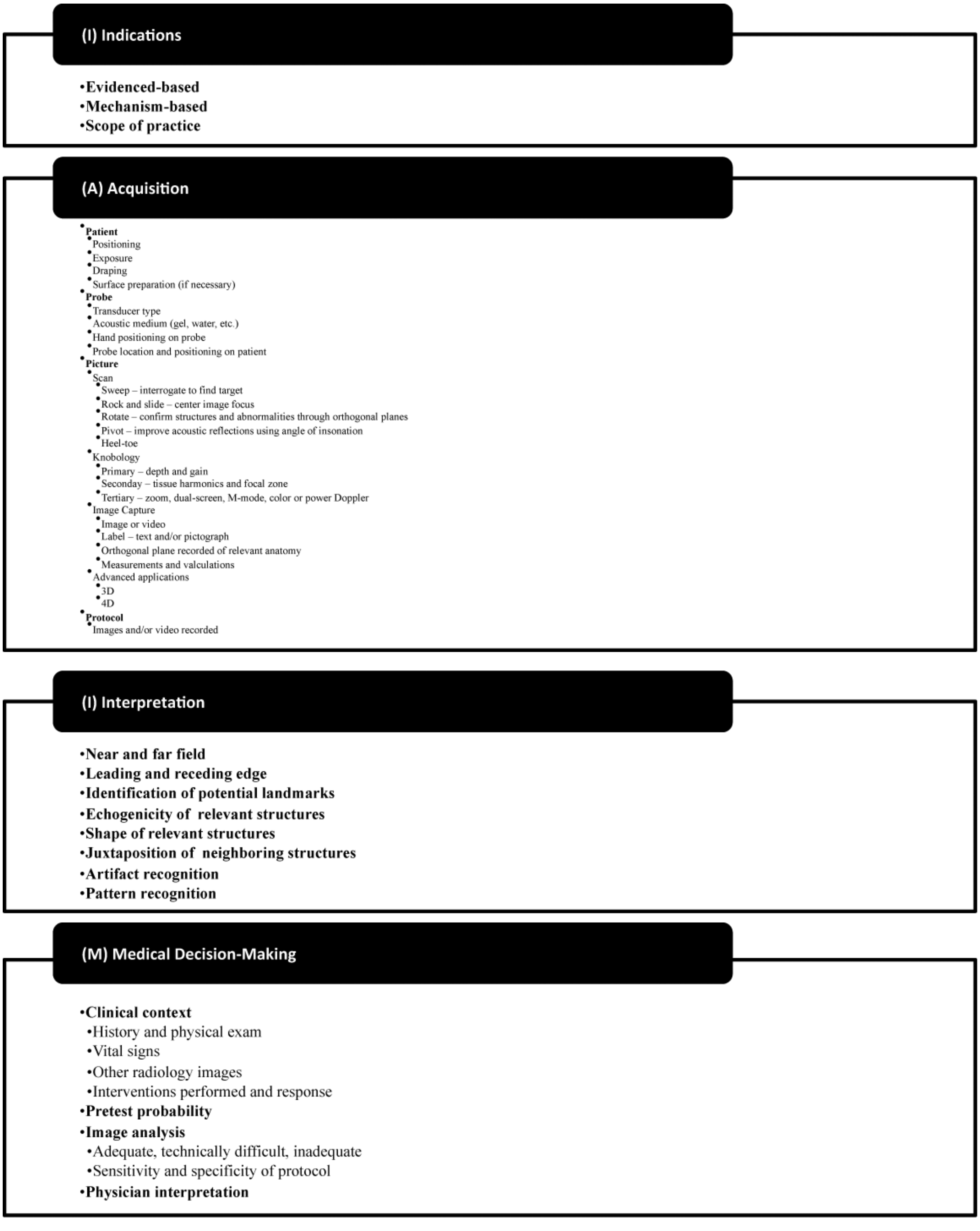
The I-AIM model divides acquisition of a high-quality focused sonographic examination into 4 primary components: (1) patient, (2) probe, (3) picture, and (4) protocol. Defining patient characteristics allows the physician to quickly and accurately perform an optimal sonographic examination while minimizing the impact to the patient. These adjustments include proper patient positioning, adjustment of ambient lighting, exposure of the region of interest, draping the patient, and any necessary surface preparation.

Probe characteristics of importance in focused sonography are selection of an ideal transducer and acoustic medium, as well as hand and probe positioning on the patient. The transducer and acoustic medium must be selected a priori because attempts to change probes or media increases time and reduces the examination quality. Furthermore, adequate media must be used to reduce wave probe-skin interface reflection. Hand positioning necessary to interrogate the target anatomy and patient-driven maneuvers (such as inhalation or exhalation) are other mechanisms which can improve the examination quality. Probe leading edge orientation congruent with accepted standards also prevents errors later during interpretation. Appreciation of ultrasonic wave attenuation and reflection in various tissues versus the need for improved image resolution can drastically alter the image quality.

The picture component focuses on the scan technique, knobology, and image capture to yield ideal images and video. Basic probe motions used to optimize the picture are sweeping to identify the target, sliding to center the target, rotating to toggle between orthogonal planes or angle around obstructions, pivoting to change the angle of insonation, and heel-toe motioning to emphasize an area of interest. Knobology is divided into primary, secondary, and tertiary functions that are used to progressively improve the examination quality. Primary functions center the anatomy of interest and enhance the ultrasonic waves using depth and gain functions, respectively. Secondary functions reduce image artifacts due to variability in ultrasonic wave physics within tissues using image filters such as tissue harmonics and focal zone adjustment, respectively. Tertiary functions then apply advanced ultrasound machine calculations to improve examination interpretation, including zoom, dual-screen, M-mode, and color and power Doppler.

Image capture ensures that necessary images and videos from focused sonographic examinations are recorded for comparison, quality review, and billing purposes. A complete examination recording includes identifiers such as labeling and pictographs, recordings of orthogonal planes of the relevant anatomy, measurements and calculations, and necessary advanced applications. Specific focused sonographic protocols can be used to identify the most important sonographic images and videos to be recorded in the patient chart.

Figure 1. I-AIM (indication, acquisition, interpretation, and medical decision making) model designed as an educational and clinical practice model for physician-performed focused sonographic examinations.



Interpretation

Sonographic interpretation necessitates a systematic approach for using acquired images to develop an understanding of a patient's anatomy. The I-AIM model initiates image analysis by evaluating the near versus far field and the leading edge versus receding edge, followed by identifying anatomic relationships. The echogenicity, shape, and relative position of structures can be useful for defining structures within an image. Artifact recognition is then used to ensure that the visualized images and measurements are truly representative of the actual anatomy. Finally, understanding the overall pattern of findings is used by advanced sonographers to recognize and differentiate sonographic results. Recognition of the differential diagnosis based solely on sonographic findings is important later within the medical decision making.

Medical Decision Making

The final task in focused sonography is determining within the clinical scenario how the image findings can be used. The I-AIM model incorporates application of the following components: (1) clinical context, (2) pretest probability, (3) focused sonographic examination interpretation, and (4) physician interpretation of all clinical parameters. The clinical context consists of the patient history and physical examination findings, vital signs, radiologic and laboratory testing, and patient interventions. Sonography typically has the greatest benefit in moderate– to high–pretest probability situations given low sensitivities and high specificities for many examinations. A comprehensive assessment of clinical data is the initial task for the physician before making a medical decision. Incorporation of the pretest and posttest probability of medical conditions given specific sonographic findings, such as pericholecystic fluid or gallbladder wall thickening in the clinical context of biliary colic, is used to assess the reliability of a specific diagnosis. The sonographic pattern is combined with clinical data at this step to develop a revised overall differential diagnosis by increasing or decreasing the probability of a condition given certain clinical and sonographic findings. After completing all other components, the physician reevaluates the clinical scenario to determine the posttest probabilities of diagnoses and determines a definitive treatment plan based on all available information. Medical management is driven primarily by the physician's differential diagnosis selection of tier 1 diagnoses and the tier 1 emergent diagnoses.

Example of I-AIM in Clinical Practice

Indication

A patient with blunt abdominothoracic trauma and hypotension after a motor vehicle collision is identified by an emergency medicine physician as having an evidence-based indication for a FAST examination.

Acquisition

The patient is placed in the supine position with exposure of the right and left hypochondriac, epigastric, and hypogastric regions while the remainder of the patient is draped with warm towels to prevent hypothermia. Either a curvilinear or phased array probe with a low frequency and ultrasound gel are selected to improve wave penetration and reduce artifact formation for deep anatomic targets such as the pericardium and kidneys. In the subxiphoid view, the hand is placed on the anterior surface of the probe because the probe will be flattened to visualize the pericardium. This view may be obstructed by a dilated stomach, requiring gastric decompression, and depending on the anatomy, recognizing that the acoustic window is optimal during the inhalation phase may improve cardiac structure visualization. A pivot maneuver is used to aim under the costal margin, using the liver as an acoustic window, followed by a rock-and-slide motion to center the right ventricle. This view is typically at 21 cm in depth; the gain should be such that the cardiac chambers are anechoic; tissue harmonics should be used given the variability of wave propagation through adipose tissue; and the focal zone is generally at the level of the anterior cardiac silhouette. Labels are then placed to identify the cardiac chambers, and video is recorded to show either the absence or presence of compressible pericardial fluid. The cumulative required images or videos that are recorded are perihepatic, perisplenic, pelvic, and subxiphoid.

Interpretation

For a perihepatic image with the probe oriented cephalad, the liver is normally in the near field and leading edge with the right kidney in the far field and receding edge. The hyperechoic diaphragm is a valuable landmark, and recognizing the heterogeneous appearance of the liver juxtaposed to the right kidney with hyperechoic fascia overlying each is useful for defining the hepatorenal potential space. The mirror image artifact of the liver above the diaphragm is a normal finding because the diaphragm is a highly reflective surface. Pattern recognition of this view will identify whether there is free fluid within the Morison pouch, no free fluid, or indeterminate fluid due to difficult visualization.

Medical Decision Making

There are many relevant history and physical examination points that precede the focused sonographic examination in the current edition of the Advanced Trauma and Life Support (ATLS) algorithm primary survey. In the current ATLS algorithm for blunt abdominal trauma, if the patient is hypovolemic and a fluid nonresponder, positive FAST examination findings indicate that free abdominal fluid is present, implying the presence of hemorrhage and therefore indicating that the patient should undergo an exploratory laparotomy.[25] In contrast, if the patient is hypovolemic and responsive to fluid interventions with positive FAST examination findings, the ATLS algorithm allows for further imaging studies such as computed tomography to better define the injury and potentially eliminate the need for an exploratory operation.[25]

Conclusions

Growth in physician-performed focused sonography applications dictates that efforts must be made to ensure that appropriate education and clinical use is developed. To date, there is no mention in the literature of any efforts to develop an educational model or clinical tool for physician-performed focused sonography. The I-AIM model has been developed to address both of these issues. Limitations of this model are that adequate validation of the design and a reliability study have not been completed; the model is currently only appropriate for English speakers; and the benefits and risks of this model have not been identified. Although these issues must be addressed before definitive recommendations can be made, this model represents the first step toward broader adoption of focused sonography for clinical practices.

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