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Proactive Medicine: The "UCI 30," an Ultrasound-Based Clinical Initiative From the University of California, Irvine

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Abstract

This article discusses the benefits of integrating point-of-care diagnostic ultrasound into the four-year medical school curriculum. Handheld ultrasound devices have been used to teach medical students at the University of California (UC), Irvine, since August 2010, and the article explains how the use of this inexpensive, safe, and noninvasive tool enhances the ability of a physician conducting a standard physical exam to confirm suspected findings and uncover other suspected pathology at a reasonable cost. The authors describe the ultrasound curriculum at UC Irvine and the process of its implementation. In the appendix to the article, the authors describe the specific diagnostic benefits of using a handheld ultrasound device for each element of the Stanford 25 physical exam. Their ultrasound-enhanced approach to the physical exam is referred to as the "UCI 30." They make recommendations for how and when to integrate ultrasound into the physical exam. The article points out that early training of medical students in the use of ultrasound can avoid the diagnostic problems of ultrasound by maximizing students' comfort and ability to obtain accurate ultrasound images for diagnostic and procedural purposes.

Teaching students to conduct a physical exam is a crucial, time-honored centerpiece of clinical medical education. However, the traditional method of performing the physical exam has not changed substantially since the introduction of the stethoscope and reflex hammer in the 1800s.[1] Physicians use their hands and basic tools, while relying on mental images of the organs that lie beneath the skin. Unfortunately, this method frequently overlooks or falsely interprets findings.[2] Correct diagnosis often depends on more expensive and potentially harmful imaging technologies.[3]

With recent technological innovations, handheld ultrasound provides a safe, portable, noninvasive, and cost-effective tool for rapidly collecting detailed diagnostic information at the point of service, whether hospital bedside or physician's office.[4] The University of California (UC), Irvine, teaching faculty values the recently described significance of the critical elements of the physical examination as expressed by the "Stanford 25" method.[5] This approach specifies the amount of information that can be gleaned from a skillful basic physical examination as performed using the basic tools well known to physicians for centuries. Similar to all other medical schools, the UC Irvine faculty teaches the complete traditional physical examination techniques during the first two years of education. However, UC Irvine has used the Stanford 25 to facilitate the introduction of ultrasound to the physician's office and the routine physical examination. We refer to our approach as the "UCI 30." Although the physical exam should not be replaced, its union with ultrasound serves to enhance the diagnosis and treatment of disease in a highly personalized and proactive manner.

Others have observed and described the ability of medical students to effectively learn to use ultrasound from focused training courses.[6–8] We believe that ultrasound training should accompany the instruction of the physical exam from the outset of medical school for all organ systems that ultrasound can effectively evaluate. This includes all parts of the Stanford 25 physical exam, as described in Appendix 1, with the exception of cerebellar testing. We recommend that ultrasound be used in evaluating all patients with any UCI 30 organ system for which there is reasonable clinical suspicion of pathology based on either the history or the physical exam. The additional information gleaned from the bedside ultrasound more precisely directs medical decision making and can save the patient the time, money, and radiation exposure that come with additional testing.

The ultrasound program at UC Irvine was introduced to first-year students at the medical school beginning in August 2010 and included Web-based lectures, peer instruction, and standardized testing. The Web-based lectures were posted on an Apple iTunes U (university) account, allowing for rapid, reliable media dissemination of the material. Weekly one-hour practice sessions, conducted during four-hour blocks to optimize the use of faculty and fourth-year student volunteers, were held for 16 weeks of the academic year. Senior medical students who took an elective ultrasound course and additional ultrasound training served as peer instructors, keeping the student:instructor ratio to an optimal level of 4:1. Faculty members supervised peer instruction by closed-circuit television and helped when needed. Image acquisition and interpretation skills were evaluated with a written multiple-choice exam and a practical exam administered to each student. Students who received ultrasound training showed significant improvements on these measures compared with those without training.[9]

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Appendix 1 describes the specific diagnostic benefits of using a handheld ultrasound device for each element of the Stanford 25 physical exam. We hypothesize that this modality will provide a powerful tool to each graduating physician to empower people to better understand and prolong their health, while providing an opportunity to attend to both harbingers and early stages of a disease long before the onset of symptoms, thereby attending to the first two tenets of public health: (1) determine disease risk and invoke measures to preclude disease development, and (2) diagnose/treat disease before the onset of debilitating symptoms.

Bedside Ultrasound: Implications for the Future

At UC Irvine, since 2010 we have integrated point-of-care ultrasound into the four-year medical school curriculum. Students in each year gain increasing facility with this modality starting in their first year with normal anatomy and physiology and progressing in subsequent years with increasing exposure to a wide array of sonographic pathology. The curriculum also includes practice performing ultrasound-guided peripheral IV insertion in the third and fourth years. We believe that this inclusion of ultrasound into the routine curriculum provides our graduating physicians with a valuable, safe, and inexpensive tool to enhance the growth of predictive, preventative, participatory, personalized (P4) medicine as embodied in Auffray and colleagues'[10] description of P4 medicine. We hypothesize that this proactive approach to the standard physician evaluation will empower individuals to prolong and protect their health, thereby ensuring their productivity and promoting their quality of life while limiting debility and delaying their entry into the health care system. Much work remains to test this concept, the first step of which is to equip a cadre of newly minted physicians with these advanced diagnostic skills that can be employed routinely in their office.

With the integration of ultrasound into the traditional physical exam, physicians are provided a safe, portable, and noninvasive tool to enhance their ability to detect medical problems and immediately confirm suspected findings at a reasonable cost. The capability to obtain and use this additional information is invaluable not only in the office but also in almost any medical setting, whether the intensive care unit, the emergency department, or the field (e.g., rural villages abroad or sites of natural disasters). However, to maximally harness the many potential applications and benefits of this simple technology at the bedside, students must be trained early in its use. By incorporating ultrasound into all four years of medical school curricula, students maximize their comfort and ability to obtain accurate images and use these images for diagnostic and procedural purposes. Early training can also avoid the diagnostic pitfalls of ultrasound and neutralize the operator dependency of the technology. These students then graduate with another tool to take with them to their residency training, armed with the skills to use this device and enhance their practice of medicine.

As the technology has advanced, the cost of entry-level ultrasound units has plummeted, from $50,000 to $7,000 to, most recently, under $200 in just five years.[11] Many still see the general dissemination of this technology to all medical students as revolutionary; we think it merely evolutionary. It is our belief that, in short order, given the progress in digital technology and the power of cloud source information, ultrasound will spread from the physician's office into the home of the general population and may well become as commonplace as today's thermometer. The old adage of "physician, heal thyself" will thus transform into "people, heal yourselves" as each person becomes ever more capable of enhancing and prolonging his or her own state of health with today's rapidly evolving mobile medical digital technology and advances in noninvasive point-of-service modalities, such as ultrasound.

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Appendix 1

UCI 30 Ultrasound Enhancements to Stanford Medicine 25: A Point-by-Point Comparison

Stanford Medicine 25	UCI 30
1. Fundoscopic exam	
• Visualize condition of retinal blood vessels—indicative of condition of vessels throughout body • Potential diagnosis of neurologic problems • Clues to systemic diseases	• Additional information obtainable on retinal detachment, detached vitreous bodies, lens dislocation, globe ruptures, foreign bodies, optic neuritis, and widened optic nerve sheath in setting of increased intracranial pressure[12]
2. Pupillary responses	
• Examine pupillary constriction and dilation in response to light • Can reveal eye trauma, neurological disease, other conditions	• Imaging of pupil constriction under a closed eyelid • Assess for relative afferent pupillary defect
3. Thyroid exam	
• Feel thyroid gland by palpating neck • Helps diagnose thyroid disease	• Directly visualize thyroid lobes • Detect much smaller tumor[13,14a] • Differentiate between solid tumors and cysts with high sensitivity and specificity[15b] • For patients with hyperparathyroidism: ◦ as sensitive and specific as MIBI in localizing parathyroid adenomas ◦ noninvasive, cost-effective screening modality[16]
4. Neck veins	
• Visualize jugular venous pulse • Can aid in diagnosis of cardiac conditions	• Noninvasive measurement of central venous pressure[17c] • Visualization of waveforms consistent with cardiac conditions
5. Pulmonary exam	
• Determine lung's boundaries by tapping the chest • Detection of fluid or pneumonia • Auscultation to detect pleural effusion, alveolar consolidation, and alveolar-interstitial syndrome	• Detection of various lung pathologies considerably better than auscultation or even chest x-ray[18,19] • Safe, rapid, cost-effective alternative to thoracic computed tomography
6. Point of maximal impulse and parasternal heave	
• Feel the beating heart and impulses originating in heart or large vessels • Detection of heart and lung problems	• Precisely locate point of maximal impulse • Increased diagnostic capabilities • Differentiate various forms of cardiomyopathy and assess dyskinesia through visualization of atrial and ventricular walls
7. Examination of liver	
• Percussion to approximate liver size • Feel liver edge, gallbladder tenderness, and gallbladder inflammation	• Trace edges of liver • Screen liver for small masses, nodularity, hepatitis, inflammation • Measure liver volume, and detect and measure hepatic masses[20] • Measure thickness of gallbladder wall and assess for inflammation, obstruction • Measure bile flow and can estimate cholelithiasis[21]
8. Examination of the spleen	
• Palpate spleen to detect various illnesses: infection, tumor, leukemias, liver disease	• Visualize spleen in entirety and accurately measure • Visualize splenic masses and characterize as cystic or solid
9. Musculoskeletal system: common gait abnormalities	
• Observe person's walk to detect nervous system and musculoskeletal problems and conditions	• Visualize musculoskeletal system: joints, tendons, and muscles • Differentiate between hip fluid collection and proximal femoral fracture • Accurately guide needle into joint space for fluid aspiration
10. Deep tendon (ankle jerk) reflex	
• Hammer used to strike Achilles tendon above the heel to detect ankle jerk reflex • Absence of reflex may indicate nerve damage	• Diagnosis of partial and complete tears of Achilles tendon[22] • Used as guide for some treatments: local anti-inflammatory injections and obliteration of local neovessels[23] • Noninvasive alternative to EMG in assessing patency of other body reflexes[24]

(*Appendix Continues*)

Appendix 1

(Continued)

Stanford Medicine 25	UCI 30
11. Stigmata of liver disease	
• Observe signs of liver dysfunction outside of abdomen (e.g., spider angiomas, parotid gland enlargement, diminished armpit hair, breast enlargement in males, testicular atrophy, clubbing)	• Liver disease detected before becoming observable on physical exam ◦ Liver inflammation detected before fulminant failure ◦ Detect ascites before "fluid shift" seen on physical exam[25,26d]
12. Internal capsule stroke	
• Series of maneuvers on body used to help identify the location of a stroke	• Visualize intracerebral vessels for plaque and flow • Visualize anterior, middle, and posterior cerebral circulation for stenosis or occlusion • Monitor effects of clot-resolving drugs[27]
13. Knee exam	
• Physical manipulation, testing, and observation of knee movement used to help determine treatment for knee injuries	• Visualize knee joint's ligaments, tendons, muscles, nerves, menisci, synovium, and articular cartilage • Can help differentiate joint effusion, abscess, or cellulitis from a septic knee joint
14. Cardiac second sounds/splitting	
• Use stethoscope to detect the S1 and S2 heart sounds and detect possible cardiac abnormalities	• Dynamically assess cardiac valves • Detect early-stage aortic and mitral valve insufficiency • Accurately measure thickness of myocardium[28] • Screen for asymptomatic hypertrophic cardiomyopathy in young athletes[29]
15. Involuntary movements	
• Identify and characterize different types of tremors and other involuntary movements	• Detection of very fine tremors and muscles fasciculations that may not be detectable by physical exam[30]
16. Hand exam	
• Examine hand for secondary manifestation of many pathologies (e.g., nerve disorders, finger deformities, and nail abnormalities)	• Detect presence and progression of erosive arthritis or tenosynovitis in patients with systemic lupus erythematosis and other rheumatic joint disease[9] • Visualize hand anatomy: joints, bones, tendons, cysts, neuromas, dislocations, fractures, and foreign bodies[31]
17. Mouth exam	
• Visually inspect tongue for swelling, unusual color or texture for signs of disease (e.g., oral cancers, nutritional deficiencies or infections)	• Imaging of structures of the mouth adds to information obtained, facilitating diagnosis of various conditions (e.g., peritonsillar and periapical abscesses, sialolithiasis, Ludwig's angina)[32,33]
18. Shoulder exam	
• Observations and maneuvers aid in diagnosis of shoulder problem such as rotator cuff syndrome or joint dislocation	• Detect dislocations, separations, and joint effusions • Visualize muscles and tendons
19. Blood pressure and pulsus paradoxus	
• Determine blood pressure and various alterations to the pulse	• Noninvasive method to measure blood pressure pulses at highly localized points in the body • Obtain beat-to-beat local pressure and flow waveform[34]
20. Cervical lymph node assessment	
• Examine neck for enlarged lymph nodes, an indication of infection or cancer	• Locate and characterize superficial and deeper neck masses[28,29] • High-resolution vessel characterization
21. Ascites	
• Palpation and percussion used to detect the presence of free fluid in the abdomen	• Detects small amounts of ascites, as little as 100 mL • "Small fluid depth" volume measurement accurately predicts amount of drainable fluid for paracentesis[25,35e]
22. Rectal exam	
• Palpate the rectal vault for detection of conditions (e.g., rectal and prostate cancers, anal fissures, hemorrhoids)	• Measure prostate size • Detect asymmetry of gland • Visualize prostatic nodules and rectal masses[36]

(*Appendix Continues*)

Appendix 1

(Continued)

Stanford Medicine 25	UCI 30
23. Scrotal mass evaluation	
• Palpate mass in scrotum for detection as to whether mass is freely movable or invading the peritesticular tissues or scrotal wall	• Can distinguish among cystic infectious masses, solid tumors, and bowel in a hernia sac • Can determine diagnosis of testicular torsion[37] • Detect pathological flow patterns • Aid in detection and characterization of perianal fistulae[38] • Visualize internal anal sphincter to assess for atrophy or small tears
24. Cerebellar testing	
• Patient goes through list of tests and maneuvers to check motor control and coordination	• No ultrasound equivalent
25. Bedside ultrasound	
• Recognized as important to physical exam	• Recognized as important to physical exam
	26. Pelvic ultrasound
	• Detects adnexal or uterine masses as small as 1 cm • Characterize free fluid in Morrison's pouch[39] • In first trimester of pregnancy, identify location of the pregnancy and provide prognostic information on fetal viability as early as five weeks' gestation
	27. Renal ultrasound
	• Visualize the kidneys and evaluate for hydronephrosis, renal cysts, renal masses, stones, or parenchymal changes in consistency[40–42f]
	28. Bladder ultrasound
	• Examine bladder, measure bladder wall thickness for sign of obstruction, and accurately determine amount of postvoid residual urine • With full bladder, diagnose bladder stones, bladder diverticula, and bladder tumors as small as 3 cm • Detect ureteric expulsion of urine into the bladder
	29. Vascular ultrasound
	• Assess health of vascular tree • Measure intimal-medial thickness of carotid artery to screen for atherosclerosis[43g] • Diagnose, and determine size of, abdominal aortic aneurysm • Detect deep vein thrombosis[44] • Visualize intra-abdominal inferior vena cava and monitor its change with respiration for estimate of central venous pressure
	30. Procedural guidance
	• Ultrasound guidance of needle into soft tissues makes the procedure safer with visually aided avoidance of important surrounding structures, timelier, and more comfortable. Examples of procedures: paracentesis, thoracentesis, arthrocentesis, pericardiocentesis, lumbar puncture, regional anesthesia, and vascular access

Abbreviations: UCI indicates University of California, Irvine; MIBI, myocardial perfusion scan; EMG, electromyography.
[a]Detects tumors of 8 mm in diameter compared with 1 cm by palpation.
[b]Sensitivity 85%; specificity 95%.
[c]Can accurately estimate central venous pressure targets of 8 to 12 mm Hg.
[d]Can detect ascites with less than 100 mL of fluid, far in advance of the "fluid shift" noted in physical exam, which typically occurs when at least 1500 mL of fluid is present.
[e]Can detect ascites in as little as 100 mL of fluid.
[f]Can detect asymptomatic renal masses of less than 3 cm.
[g]Measurement of thickness of intimal-medial carotid artery is a reliable harbinger of stroke potential.