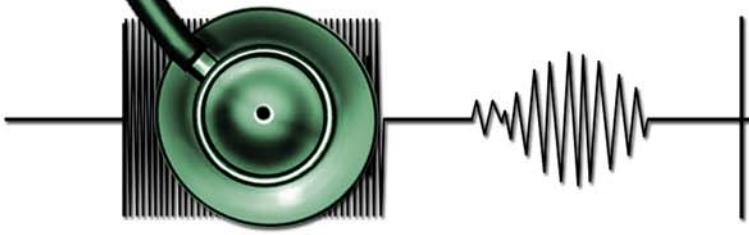
Instructor Guide

Harvey®

the Cardiopulmonary Patient Simulator



UNIVERSITY OF Miami
SCHOOL OF MEDICINE

Center for Research in Medical Education

HARVEY INSTRUCTOR GUIDE

"The M.I.A.M.I. Group"

The **M**iami **I**nternational **A**lliance for **M**edical-Education **I**nnovation

DEVELOPERS

Michael S. Gordon, M.D., Ph.D.
Associate Dean for Research in Medical Education
Professor of Medicine (Cardiology)
Director, Center for Research in Medical Education
University of Miami School of Medicine

S. Barry Issenberg, M.D.
Assistant Dean for Research in Medical Education
Associate Professor of Medicine
Director, Educational Research and Technology
Center for Research in Medical Education
University of Miami School of Medicine

CONTRIBUTORS

Gordon A. Ewy, M.D.
Professor of Medicine
Chief, Section of Cardiology
Director, Sarver Heart Center
University of Arizona College of Medicine

Joel M. Felner, M.D.
Associate Dean for Clinical Education
Professor of Medicine
Emory University School of Medicine

Robert A. Waugh, M.D.
Associate Professor of Medicine
Department of Medicine
Duke University Medical Center

Ira H. Gessner, M.D.
Professor of Pediatrics
Eminent Scholar Emeritus, Pediatric Cardiology
University of Florida College of Medicine

Robert E. Safford, M.D., Ph.D.
Barbara Woodward Lips Professor of Medicine
Chair, Department of Internal Medicine
Mayo Clinic Jacksonville

Donald D. Brown, M.D.
Professor of Medicine
Division of Cardiovascular Diseases
University of Iowa Hospital & Clinics

Stuart Rich, M.D.
Professor of Medicine
Director, Center for Pulmonary Heart Disease
Rush Heart Institute / St. Luke's Medical Center

David Lee Gordon, M.D.
Assistant Director / Director Neurology Training
Center for Research in Medical Education
Professor of Neurology and Medicine
University of Miami School of Medicine

Stuart D. Pringle, M.D.
Professor of Cardiology
Honorary Senior Lecturer
University of Dundee

Ronald M. Harden, M.D.
Professor of Medical Education
Director of Education
International Virtual Medical School (IVIMEDS)
University of Dundee

Emil R. Petrusa, Ph.D.
Associate Dean for
Curriculum Evaluation and Assessment
Duke University School of Medicine

William C. McGaghie, Ph.D.
Professor of Medical Education
and Preventive Medicine
Northwestern University Medical School

Ross J. Scalese, M.D.
Assistant Professor of Medicine
Assistant Director, Educational Research and Technology
Center for Research in Medical Education
University of Miami School of Medicine

Contents

Page

Overview

This Instructor Guide has been created to share our long experience with our colleagues who use Harvey to teach. We trust this guidance will assist you and, most importantly, will result in the optimal use of the simulator for the benefit of your students.

Harvey has been used for teaching and assessing bedside cardiac skills for over 30 years. The simulator and all the accompanying learning materials have been created and are continuously updated at the University of Miami with a consortium of physicians and educators representing medical centers worldwide.

Three manuals are included with Harvey:

- this *Instructor Guide* that outlines the optimal use of Harvey for those responsible for teaching with the simulator
- a *Harvey Learner Manual* that includes all of the findings in Harvey's 30 diseases for both learners and teachers
- a *Technical Manual* that provides information on maintenance and troubleshooting

Additional teaching materials include:

- *slide programs* for each disease that guide the learner through each case
- *multimedia computer programs* (UMedic) that may be linked to Harvey and thus save instructor teaching time – while acquired as an option, this is the preferred method for self-learning

THE IMPORTANT MESSAGES CONTAINED IN THIS GUIDE ARE:

- that Harvey will teach and test cardiopulmonary bedside skills that transfer to real patients
- that Harvey and the teaching materials associated with the simulator will also teach and test pathophysiology, laboratory evaluation, differential diagnosis and treatment
- that Harvey may be used to train many different types of healthcare professionals at many different levels of their training and in many different settings
- that each institution should have a Harvey "Champion" - a clinician-teacher who ensures the simulator's appropriate use
- that the appropriate use of Harvey must include integration into the required curriculum and the testing of outcomes

If the above messages are accepted and followed, your students will not only learn, they will enjoy the experience, and they will thank you.

About This Guide

Background

Why there is a need for this guide

Numerous simulators have been developed and used in a wide variety of medical disciplines for multiple populations of learners. Several publications have been written about the use of simulators and their advantages as teaching and assessment tools. Our consortium of physicians and medical educators felt it was time to develop a practical guide to disseminate information to individuals who are responsible for integrating Harvey, the Cardiopulmonary Patient Simulator, into the curriculum at their institution, and to individuals who will have specific responsibilities relating to the use of Harvey. The information in this guide is based on our consortium's 30-year experience in developing and using the simulator, as well as the results from a worldwide survey of Harvey users.

Aims of this Guide

- disseminate information about the most effective uses of Harvey to teach and test
- provide advice to administrators and teachers relating to logistical, educational and technical issues
- provide suggestions for research and for the further development of Harvey

The development of this guide has been stimulated by the current acceptance of simulation technology in medical education and by recent events that demonstrate the ongoing acceptance and success of Harvey, including its use throughout the curriculum. These include:

- an increase in the number of institutions obtaining Harvey, including the British Heart Foundation's placing Harvey at all of the medical schools throughout the United Kingdom
- numerous requests by recent Harvey users for information reflecting the experience of other institutions that use the simulator
- the increasing number of studies that show the use of Harvey increases learning, teaches bedside skills that transfer to real patients, and is an effective testing instrument
- the suggestion by the American College of Cardiology Task Force on Education that Harvey should be integrated into the day-to-day teaching of clinical cardiology
- the decision by the American Board of Internal Medicine to develop a multimedia computer system to assess bedside skills as part of recertification - video clips of Harvey are included as examples of cardiology bedside findings

It is anticipated that an additional benefit of this guide will be the collaboration between Harvey user institutions with regard to the teaching and learning of the cardiovascular system in the medical curriculum.

Contents of this Guide

This guide has been divided into fourteen sections. You can choose to read through the booklet systematically, or skim through it reading the sections that are of particular interest.

- **About This Guide** – the purpose of this guide and its contents
- **What Is Harvey?** – the features and capabilities of the simulator as well as add-ons that increase the effectiveness and use of Harvey
- **Why Use Harvey?** – a short review of shortcomings in medical education, the resultant deficiency in clinical skills, and how simulators have been used to address some of these issues
- **Harvey Location & Allocating Responsibilities** – suggestions on practical issues such as the optimal approach for locating and providing access to Harvey, setting up the learning environment, and allocating responsibilities to those who will teach and maintain the simulator
- **A Guide To Using Harvey** – instructions on the operation and optimal use of the simulator
- **Using Harvey In Different Contexts** – an account of the wide range of uses that Harvey can fulfill at a medical institution
- **Integrating Harvey into the Curriculum** - practical tips on introducing Harvey throughout medical school and suggestions on how to ensure the greatest use of the simulator
- **Using Harvey As An Assessment Tool** – practical advice on how to use Harvey as an assessment tool, including the range of testing methods and instruments that may be used with Harvey
- **Using Harvey In Research** – listing of previous studies involving Harvey and an outline of suggestions for further areas of research
- **Use in Public Relations** – brief description on creative ways institutions have used Harvey
- **Misconceptions About Simulators and Harvey** - some common myths and misconceptions regarding the use of simulators in medical education
- **Conclusion** – some final words about using Harvey and this guide
- **References** – where you can read more about the use of Harvey
- **Appendices** – information regarding the specific findings in Harvey and examples of its use in the curriculum (for exact details of findings in each disease, see *Harvey Learner Manual*)

What Is Harvey?

Description of Harvey

Harvey, the Cardiopulmonary Patient Simulator, is a life-sized mannequin *(Figure 1)* that provides a comprehensive cardiology curriculum by realistically simulating 30 cardiac conditions. Unlike a real patient, it is always available and is never tired, worried or abused. Interesting, instructive, or even rare cases may be called up in a matter of seconds. The student may learn at his/her own rate and become personally involved in the evaluation, acquiring skills as well as cognitive information. The student may control the number of variables being taught, thus reducing the background "noise" that often overwhelms a student dealing with real patients.

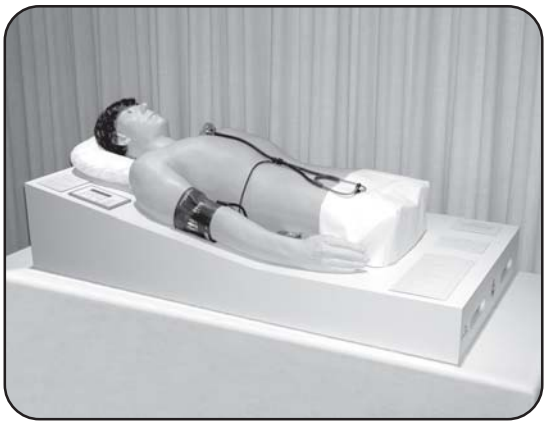


Figure 1. Cardiopulmonary Patient Simulator

For each disease, the Cardiopulmonary Patient Simulator specifically demonstrates the following bedside findings:

Arterial and Jugular Venous Pulses *(Figure 2):*

- **Blood Pressure** – right arm
- **Bilateral jugular venous pulse wave form**
- **Arterial pulses** including:
  a. Carotids – bilateral
  b. Brachials – right
  c. Femorals – bilateral

Pulse configurations vary appropriately for each disease.

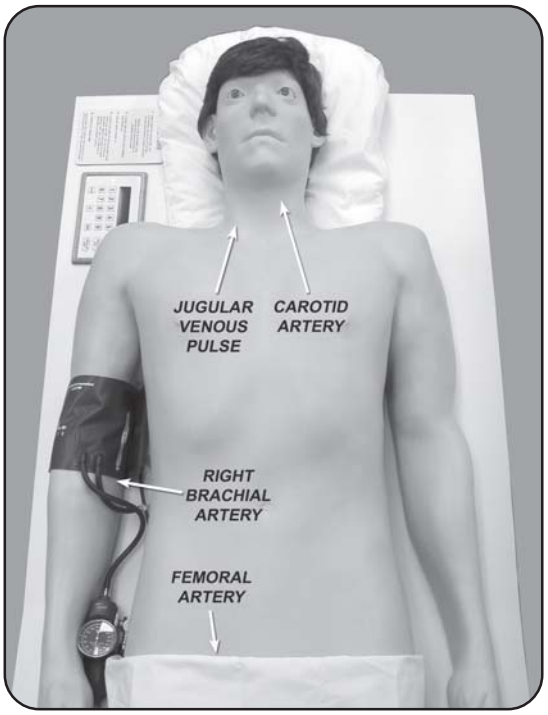


Figure 2. Venous and Arterial Pulses

Precordial Movements *(Figure 3):*

a. Pulmonary area (upper left sternal edge)
b. Right ventricular area (mid and lower left sternal edge)
c. Left ventricular area (apex - 5th left intercostal space, midclavicular line)
d. Displaced left ventricular area (6th and 7th left intercostal space, anterior axillary line)

Within each area, multiple movements appropriate for a given disease may be simulated.

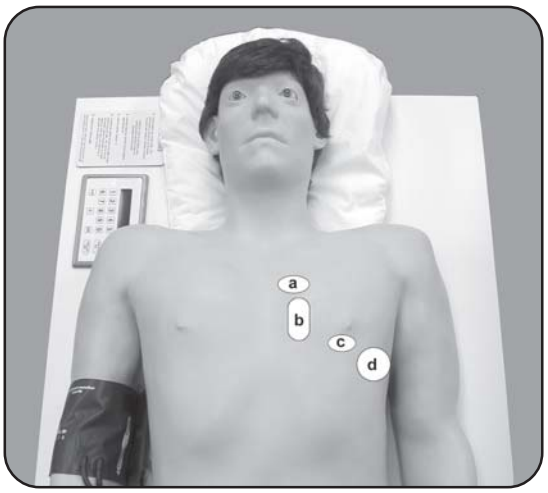


Figure 3. Precordial Movements

Cardiac Auscultation *(Figure 4)* – the auscultatory areas represented include:

a. Aortic area (upper right sternal edge)
b. Pulmonary area (upper left sternal edge)
c. Tricuspid area (lower left sternal edge)
d. Mitral area (apex)
e. Mitral radiation (posterolateral to apex)
f. Aortic or pulmonary radiation (upper chest)
g. Carotids

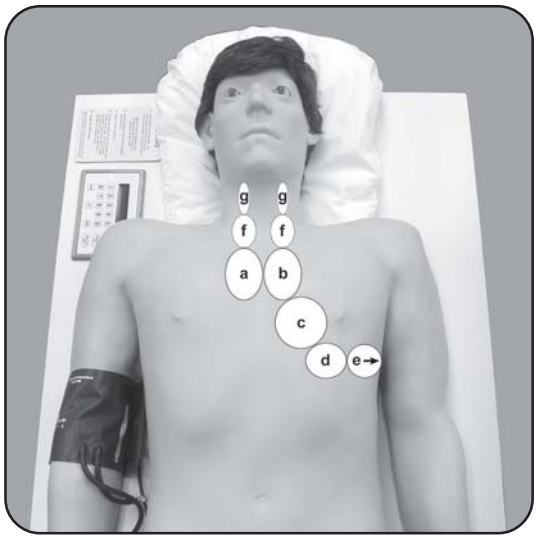


Figure 4. Cardiac Auscultation

Pulmonary Auscultation *(Figure 5)* – the pulmonary auscultatory areas represented include the following lung fields:

a. right upper
b. right inferoposterior
c. right inferoanterior
d. left upper
e. left inferoanterior
f. left inferoposterior

Pulmonary findings match the cardiac disease presented.

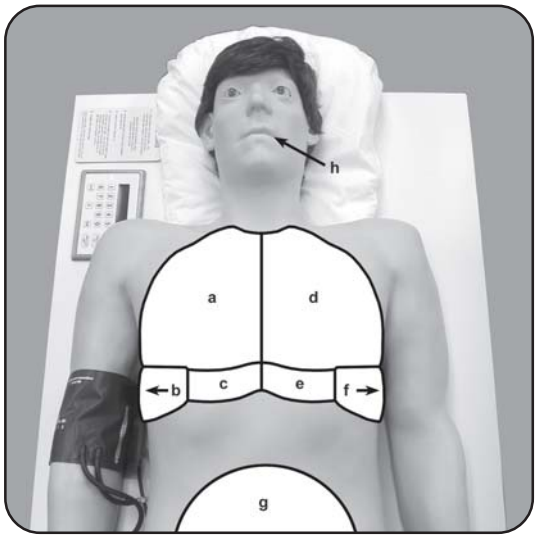


Figure 5. Pulmonary Auscultation

Respiration *(Figure 5):*

g. Abdominal breathing is simulated

All the areas of movement and the cardiac acoustic events are synchronized, and the cardiac acoustic events vary with respiration when appropriate. The heart rate is 60 beats per minute and the respiratory rate is 12 cycles per minute for all diseases.

Talking *(Figure 5 & 6):*

h. A built-in speaker allows an instructor, through the use of a wireless microphone that is provided with Harvey, the option to respond to history questions posed by the learner.

Figure 6. Instructor responds to learner questions through the use of a wireless microphone

Curricular Slide Programs

A series of slide programs is included with Harvey, the Cardiopulmonary Patient Simulator. The programs are presented in Power Point format and accessible via a menu after they have been installed on a computer. The programs present background data in a question and answer format for each of the 30 diseases that is programmed in Harvey. These background data include the history, physical findings, electrocardiograms, X rays, echocardiograms, and hemodynamic, therapeutic, pathologic and epidemiologic information. The slides sequentially guide the learner through each case and conclude with a summary of the disease and a review of the case presented.

Manuals

Three manuals are included with Harvey:

- this *Instructor Guide*
- a *Harvey Learner Manual* that includes the entire curriculum with a summary of all of the findings for each of the 30 diseases programmed in Harvey
- a *Technical Manual* that provides information on maintenance and troubleshooting

Accessories are available that can increase the effectiveness of Harvey. While they are not necessary to use Harvey, they have been shown over the past 25 years to greatly improve instructor productivity and student learning. These include:

UMedic Multimedia Computer Curriculum

The UMedic Multimedia Computer Curriculum in Cardiology is available for use with Harvey. The UMedic system saves instructor teaching time by presenting interactive real-time patient evaluations based on Harvey. The system also documents learner performance, and a national multicenter study has demonstrated a highly significant increase in the bedside skills of learners using the system.[1] While Harvey teaches without an instructor as a stand-alone unit, it is definitely more effective for self-learning when linked to the UMedic system *(Figure 7)*.

Figure 7. Students training with Harvey linked to UMedic

Sound Transmission System

In order for a group of learners to simultaneously learn from Harvey, a remote audio system with individual headphones should be obtained *(Figure 8).* Because this will enable multiple users to auscultate at the same time, it enhances teacher-student interaction and is necessary for group participation. Depending on the audio system and the number of headphones obtained, any number of users, from a small group of five to a large auditorium of over 200 may "auscultate" simultaneously.

Figure 8. Students using infrared stethophones

We suggest either one of two possible systems, with a minimum of 10 headsets for the system you choose. The first uses infrared light and has been used for many years with excellent results. The second uses FM radio. It has more recently become available, and our initial experience with the system is also excellent.

Advantages of the FM transmitter system compared to the infrared system include:

- the lower cost for 10 headsets for small group learning – the savings would increase if more headsets are purchased
- the headphones are more comfortable if used for prolonged periods of time
- the nearly universal availability of FM receivers – acceptable headphones may be purchased at any electronics store

Disadvantages of the FM transmitter system compared to the infrared system include:

- the potential for theft of the FM receivers that also function as radios
- the headphones do not fully simulate the look and feel of a stethoscope

Why Use Harvey?

Problems with Traditional Approaches to Clinical Teaching

Reduced Numbers of Patients as Resources for Clinical Teaching

Changes in the delivery of healthcare have resulted in a major shift in the approach to medical education. The pressures of managed care have permanently changed the nature of hospitalizations, with higher percentages of acutely ill patients and shorter inpatient stays. The result is less opportunity for learners to adequately assess patients with a wide variety of diseases and physical findings.

Increased Demands of Clinician-Educators

Outpatient care has become more cost-efficient, but reductions in physician reimbursement and shrinking financial resources have placed greater constraints on the time that experienced clinician-educators devote to medical education in this environment.

Increased Demand for Vertical Integration of the Curriculum

Curricular reform typically demands increased patient contact in the early years of the curriculum to provide a clinical context for the basic sciences. As a result, students in all phases of the curriculum are competing for meaningful patient contact at a time when fewer patients are available.

Increased Need for Time-Effective Training

Under the present system of medical education, students find it increasingly difficult to keep abreast of those topics already included in the curriculum, which is itself overcrowded. Opportunities for student learning need to be readily available in order to maximize the time-effectiveness of their training. However, student logs show students spend less than 5% of ward rounds demonstrating their physical examination skills, as patients and charts are often unavailable.

Result - Poor Clinical Skills Training

These problems are having a direct effect on clinical skills training, including bedside cardiology. Despite evidence that accurate clinical examination of patients with cardiac signs and symptoms is a cost-effective diagnostic modality,[2,3] direct bedside teaching of these skills is occurring with decreasing frequency.[4] We believe the inevitable result is a decline in the quality of physicians' bedside skills and a reduction in the ability to provide high-quality and cost-effective medical care. The loss of clinical acumen was documented in a recent study that demonstrated house officers have difficulty identifying common cardiac findings.[5] That study also stressed the need for structured, supplemental strategies to improve clinical education.

Simulators as an Answer

Non-medical Simulators

Similar problems in other fields have been solved by using simulation techniques. Examples include flight simulators for pilots and astronauts,[6-8] war games and training exercises for the military,[9] and management games for business executives[10] and technical operation of nuclear power plants.[11]

Simulations are not identical to "real life" events. Instead, simulations place trainees in lifelike situations where they receive feedback about their performance and the results of these decisions. There is no doubt that simulation techniques are valuable for teaching. Airlines are convinced of the value of the flight simulator for pilot training because these sophisticated devices closely approximate in-flight situations. Working on a flight simulator has been shown to greatly improve pilot skills.[12,13]

Value of Medical Patient Simulators

Patient simulations can reproduce a wide variety of medical conditions. Simulators are not intended to replace real patients. However, they can address the disadvantages inherent in a totally patient-dependent curriculum. The disadvantages include:[14]

- unavailability of patients demonstrating known diseases at a specific time in the curriculum schedule
- embarrassment and stress to patients and beginning students
- reluctance among patients to participate in an examination where they are exposed to a large number of learners
- unpredictable patient behavior because their physical signs of disease may change and their overall condition may deteriorate
- lack of standardization of patients with unstable disease, resulting in the students' assessment on one patient being a very different experience than on others

Harvey as a Simulator

There are two requirements for mastery of the beside examination used in patient diagnosis and care. First, skills must be practiced repetitively, and second, trainees must have an orderly examination technique together with knowledge of the hemodynamic correlations with bedside findings. Traditionally, this had required a pool of "teaching" patients with diverse diseases at different stages of severity and treatment combined with instruction by experienced physicians who are motivated to teach. As described above, these requirements have become difficult and often impossible to meet. As a response to these challenges, the MIAMI Group began work over 30 years ago to develop Harvey, a simulator capable of reproducing the bedside findings of almost all cardiac diseases instantly and with high fidelity.

High fidelity simulations such as Harvey are often seen only as a tool for students to gain experience in psychomotor clinical skills in a non-threatening environment. Experience with Harvey has shown that it can be used for a much wider range of educational outcomes. Once the psychomotor skills are developed and a given bedside finding is identified, the student may also learn to integrate the pathophysiology, define a differential diagnosis, estimate severity and make management decisions.

Harvey Location & Allocating Responsibilities

Physical Location

One of the most important conclusions of our user survey was that the location of Harvey directly correlated with its use throughout the curriculum. The location should be convenient for both students and the faculty person-in-charge. Even though Harvey functions as a self-learning device, the nearby presence and availability of knowledgeable faculty and staff ensure a successful program.

Locations that Contribute to Harvey's Success:

- Clinical Skills Center
- Dedicated small classroom in Medical Education Center
- Dedicated small classroom in main teaching hospital
- Standardized Patient Center, especially for Harvey "Talking" Feature

Locations that Contribute to Harvey's Lack of Use:

- Library setting
- Off-site clinic location remote from other learning activities
- Non-dedicated small classroom in which other educational activities are scheduled

"Students have to visit the education center located 1 hour from hospital"

"We have no permanent room so everything has to be detached and stored..."

Comments from Harvey users

Access to Harvey

The majority of institutions have restricted hours for the use of Harvey. About one-fourth of the schools have unrestricted hours. There are advantages and disadvantages to both of these methods.

Issues Related to *Restricted* Access to Harvey

- This limits the potential off-peak hours for practice with Harvey, e.g., evenings and weekends.
- Allows for greater degree of control over the surveillance of Harvey - damage is less likely to occur when others are around.
- Conflicts in scheduling Harvey's use for multiple groups of learners are more likely to occur.
- Many schools have found it helpful to implement a "sign up" schedule for access time when Harvey is not being used as part of a core learning activity.

"We often have competing groups of learners within the same time period - this can sometimes be a bit chaotic."

"A common logistical problem is scheduling multiple groups who wish to use him."

"Students sometimes complain that they cannot use Harvey during the weekends when they have more free time to practice their skills."

Comments from Harvey users

Issues Related to *Unrestricted* Access to Harvey

- This increases the potential off-peak hours for practice with Harvey, e.g., evenings and weekends.
- Allows for less degree of control over the surveillance of Harvey - damage is more likely to occur when others are not around.
- Conflicts in scheduling Harvey's use for multiple groups of learners are less likely to occur.
- Some schools have found it helpful to implement an electronic access card system to allow entry to the room.

"Allowing evening access to Harvey increased the amount of time groups of students could practice on Harvey."

"When we allowed access on weekends, Harvey was vandalized - someone had attempted CPR on it and caused considerable damage."

"Evening access to Harvey has enabled some busy clinicians to teach students who might otherwise not be able."

Comments from Harvey users

Comment: With either system, the key factor is a person designated to control the schedule and briefly orient learners.

Learning Environment

Harvey may be used for teaching in any environment in which a patient may be examined. Individuals or small groups with stethophones may learn without an instructor by using the self-assessment slide programs or the UMedic system *(Figure 9)*. Larger groups may learn in a lecture hall setting by using stethophones for auscultation and video cameras and monitors or a projector for observing other physical findings.

Figure 9. Harvey and UMedic in Small Learning Room

Harvey may be permanently housed in a variety of settings. If the area is only for Harvey, it should be about the size of a patient's small hospital room, so that space is available for small group "Bedside Rounds." Harvey may also be used in clinical skills or simulation training centers that house other skills/simulation training systems. While special facilities are not required to use Harvey for history-taking, Standardized Patient (SP) training areas facilitate such use. Most importantly, the location should be convenient for both students and the faculty person-in-charge. Even though Harvey functions as a self-learning device, the nearby presence and availability of knowledgeable faculty and staff will ensure a successful program. A motivated secretary that appropriately represents the teacher-in-charge can manage the educational programs associated with Harvey. The simulator is portable and may be moved to a lecture hall or transported out of the building in which it is housed to other sites.

Learning Environment Suggestions

- About 10'x15' room that can be locked
- PC on table or stand - for slide programs and/or UMedic computer system
- Chalk Board (do not get ink on Harvey's skin)
- Infrared or FM remote audio transmission system with 10 headsets
- Desk chairs for lecture style teaching session
- Do not allow any food or drinks in room
- Optional - ceiling mounted camera/microphone to record patient-student encounter

Allocating Responsibilities

Academic

Appoint one faculty member who is responsible not just for the use of Harvey in one specific course but for integrating the use of Harvey into the curriculum. Schools that have been most successful at fully integrating Harvey throughout the entire curriculum have such a "champion" of Harvey, who is typically a clinician who believes in the value of the bedside examination, enjoys the teaching of bedside skills, and often directs a related component of the curriculum.

Administrative

Appoint an administrator of Harvey (someone who works closely with the academic "champion" of Harvey). Administrative responsibilities relating to Harvey include:

- briefly orienting students and providing them with appropriate instructions
- scheduling the use of Harvey
- liaising with faculty to facilitate teaching and learning sessions
- working with the technician to keep records related to the maintenance of Harvey

Maintenance

There are no maintenance requirements other than cleaning the skin with rubbing alcohol and lightly powdering the skin daily with use. Users should be advised to wash their hands prior to use and refrain from bringing food or drinks into the area. In the event of a malfunction or need to adjust the unit, a person with basic computer skills may be needed to get technical support from the University of Miami Center for Research in Medical Education.

A Guide To Using Harvey

The administrator or faculty "champion" should orient students as outlined below:

Important Suggestions to Prolong the Life of Harvey

- Please treat Harvey with the same respect you would a live patient - gently. (DO NOT GIVE CPR!)
- Do not put pressure on abdomen.
- Keep ink, marking materials, printing materials and the stethoscope tubing away from the skin, as marks cannot be removed. Your hands must be clean before using Harvey.
- Do not attempt to move the hands or to remove or reposition the blood pressure cuff.
- While Harvey is portable, exercise care when moving to protect internal circuitry and mechanics.
- If you have any technical problems or questions, please make a record of the problem and contact the person in charge.

Operation

Controls and Indicators

The controls and indicators are found in the keypad next to Harvey's head as illustrated in *Figure 10*. Their functions are described in the instructions next to the keypad on Harvey and are shown below. The volume keys control the volume of both the stethoscope and any stethophones that may be used by multiple learners. Stethophones may be linked to Harvey by plugging in to the "audio out" outlet at the lower right end of the foot of Harvey's cabinet.

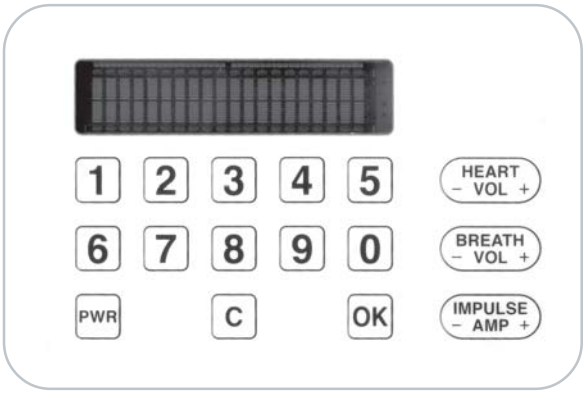


Figure 10. Keypad

Directions for operating Harvey

1. Power on: press **PWR** - The system will initialize by stating *"Please wait while loading sounds."* Disease code 46 (Normal) will appear with instructions to *"examine patient now."*
2. Change disease: enter code number and press **OK.**
3. Cancel entry: press "**C.**"
4. Change volumes or impulse amplitude: press **VOL** or **AMP** - or + as often as required. (When changing to a new disease, they will automatically return to a preset level.)
5. Power off: press **PWR.**

NOTE 1: Harvey will turn off two hours after the last keypad entry. To turn on again, press **PWR**.

NOTE 2: While the amplitude and volume of the impulses and sounds are preset, the controls allow changes. Findings may be made more subtle or exaggerated and the "background" noise of the breath sounds may be eliminated for teaching purposes.

Use of Learner Manual with Harvey

The Harvey Learner Manual provides the most straightforward method for students to learn the typical findings of the 30 different cardiac conditions programmed into Harvey. The first section of the manual describes the capabilities of Harvey, how to operate the simulator, and the technique of examination. The second section is a guide that describes the exact findings in each condition, explains the underlying pathophysiology, and presents a graphic representation for each finding.

Use of Slide Programs with Harvey

The PowerPoint slide programs for each disease are an excellent source of instruction, as they present the bedside findings along with historical, laboratory, therapeutic, pathologic, and epidemiologic data in a self-assessment format. After installing the Harvey Curriculum Program (instructions are included on the CD-ROM insert), double-click the "Harvey Curriculum" icon on your computer's desktop; a menu listing the conditions will appear. For any condition that is chosen, the slides will provide background data and a clinical context for Harvey's bedside findings.

Use of UMedic with Harvey

The UMedic computer programs provide an interactive, multimedia-rich, teaching and testing resource. Because of the instructor time saved, UMedic is the preferred method of self-learning when used in conjunction with Harvey. The UMedic system should be placed in close proximity to Harvey as shown in *Figure 7.* The instructions for the use of UMedic linked to Harvey are the same as those when UMedic is used alone and are detailed in the UMedic User Manual. Important exceptions include:

- Be sure to call up the disease code in Harvey that matches the UMedic CD-ROM.
- Use Harvey's stethoscope or stethophones when you are instructed to listen to Harvey's heart sounds and murmurs.
- Either speakers or headphones can be used for the audio portion of the UMedic system. Speakers are convenient, since Harvey's stethoscope or stethophones will also be used. However, the fidelity of the heart sounds and murmurs in the UMedic system will be enhanced if headphones are used.

Use of the "Talking" Feature with Harvey

Harvey can "talk" through a built-in speaker and wireless microphone, thus becoming a complete standardized patient (SP), representing both the history and physical examination. The histories in the PowerPoint and UMedic programs provide a basis for SP instructional materials that can be used for the "talking" feature of Harvey. Materials from an established SP program can also be used. The history can be given through the wireless microphone from a nearby location in which the learners' responses can be heard. This is facilitated if the room housing Harvey also functions as an SP training facility and is equipped with a microphone to transmit the learners' voices *(Figure 6).*

Conditions / Findings Available

There are 30 cardiac conditions comprising over 200 different bedside findings programmed into Harvey. The conditions are listed below. The curriculum is structured to begin with common, less complex conditions and progress to more rare and complex diseases. Appendix A outlines the categories of findings, (i.e., jugular pulses, precordial pulses, etc.) and includes examples for each category.

Harvey Curriculum	
Introductory Program	Mitral Stenosis with mild tricuspid regurgitation
Normal	Mitral Stenosis & Regurgitation
Innocent Murmur	Aortic Regurgitation, chronic
Aortic Valve Sclerosis	Aortic Regurgitation, acute
Hypertension	Aortic Stenosis
Angina Pectoris	Hypertrophic Obstructive Cardiomyopathy
Acute Inferior Myocardial Infarction	Cardiomyopathy
Acute Anterior Myocardial Infarction	Acute Pericarditis
Ventricular Aneurysm	Primary Pulmonary Hypertension
Mitral Valve Prolapse	Atrial Septal Defect
Mitral Valve Prolapse, Isolated click & murmur	Ventricular Septal Defect
Mitral Regurgitation, chronic	Patent Ductus Arteriosus
Mitral Regurgitation, mild	Pulmonary Stenosis
Mitral Regurgitation, acute	Coarctation of the Aorta
Mitral Stenosis with severe tricuspid regurgitation	Tetralogy of Fallot

How to Examine Harvey and Demonstrate the Findings

The faculty member should be familiar with the following description and orient students as necessary.

Five Fingers of Clinical Diagnosis

The approach to examining Harvey is the same as for a patient. When coupled with the accompanying PowerPoint programs or linked to the UMedic Multimedia Computer Curriculum, all of the data available from a patient is presented. This is embodied in the "Five Fingers of Clinical Diagnosis" *(Figure 11).*

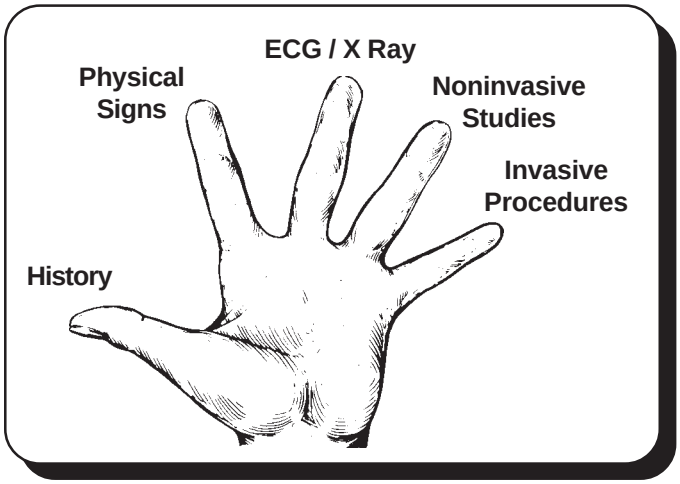


Figure 11. Five fingers of clinical diagnosis

Five Fingers of Physical Signs

The cardiac physical signs of each disease are presented by Harvey according to the outline indicated in "The Five Fingers of Physical Signs" *(Figure 12).* The pulmonary examination should include careful auscultation in all lung fields. These outlines are carefully followed for each disease state simulated by Harvey. They are excellent guidelines for a thorough cardiopulmonary physical examination. They also embody the essence of clinical medicine, as the history and physical examination form the cornerstone of patient management. In addition, noninvasive and invasive procedures are best interpreted in the context of a complete bedside patient evaluation.

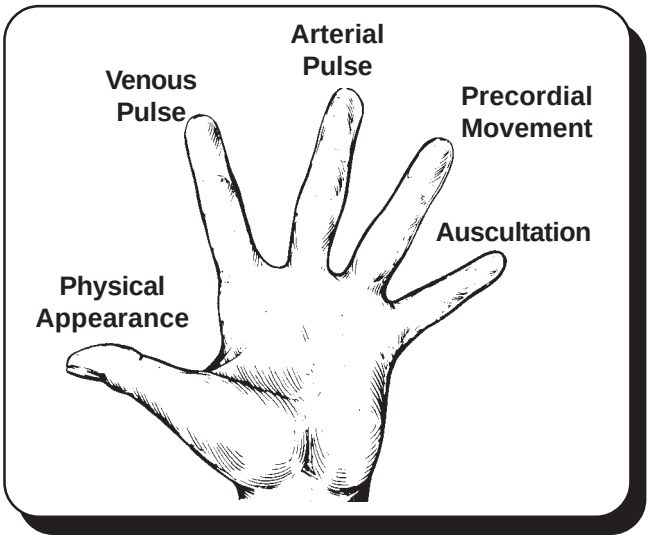


Figure 12. Five fingers of physical signs

General Appearance

The general appearance of each patient simulated by Harvey is described or graphically demonstrated in the slide programs, in the UMedic system and in the Learner Manual.

Venous Pulses

The venous pulse is evaluated by inspection of the internal jugular veins which directly reflect right atrial dynamics. They are observed (not palpated) as they undulate at the inferolateral aspect of the sternocleidomastoid muscle. There are two types of information that can be obtained from the venous pulse: mean central venous pressure and wave form.

The mean central venous pressure varies only slightly in Harvey. The exact level is given for each disease in the accompanying slide program and in the UMedic system. The venous wave form is exactly simulated. The wave form is assessed by timing its movement with the carotid pulse (which lies higher in the neck just medial to the sternocleidomastoid muscle) or with the heart sounds. The venous pulse may be identified by its anatomic location. A small penlight may be used to beam a tangential light source on the jugular venous pulse to better visualize the venous wave form *(Figure 13).*

Figure 13. Assessing the Jugular Venous Pulse with Tangential Light while Timing with the Carotid Impulse

Arterial Pulses

Assessment of the arterial pulses includes taking the blood pressure and palpating the pulses.

As with a patient, the blood pressure is taken by first palpating the right brachial artery at the medial aspect of the antecubital fossa. The stethoscope diaphragm is then placed over the artery and the cuff inflated *(Figure 14)*. While slowly deflating the cuff and simultaneously listening through the stethoscope, the sphygmomanometer is observed to determine when the Korotkoff sounds begin and end.

Figure 14. Blood Pressure - Placement of Stethoscope Diaphragm on Brachial Artery and Inflation of Cuff

The carotid arterial pulse should be lightly palpated high in the neck just medial to the sternocleidomastoid, assessing its upstroke, peak and downstroke. The right brachial and the femorals should be examined subsequently. The right brachial should be palpated simultaneously with the femoral to detect diminution or delay in the latter as a clue to coarctation of the aorta *(Figure 15)*.

Figure 15. Simultaneous Palpation of the Brachial and Femoral Arteries

Precordial Movements

The areas of movements have been described along with their locations *(Figure 3)*. The observer should GENTLY palpate the chest wall in all of these areas. Multiple movements may occur, both in systole and diastole. It is necessary to simultaneously palpate the carotid and/or listen to the heart sounds to time these palpable precordial movements *(Figure 16).*

Figure 16. Precordial Movement - Simultaneous Auscultation and Palpation

Auscultation

After having assessed the venous, arterial and chest wall pulsations, the acoustic events may be analyzed. The auscultatory examination is commonly begun at the aortic area, with the stethoscope then inched to the pulmonary area, tricuspid area and mitral area. Also listen for posterolateral radiation of mitral murmurs, superior radiation of aortic murmurs and for carotid bruits. It is helpful to simultaneously palpate the carotid to time the acoustic events *(Figure 17).* Great care should be used to exactly time all of the murmurs and to assess their:

- timing in cardiac cycle
- intensity
- frequency
- configuration
- quality
- duration
- radiation
- variation, if any, with respiration

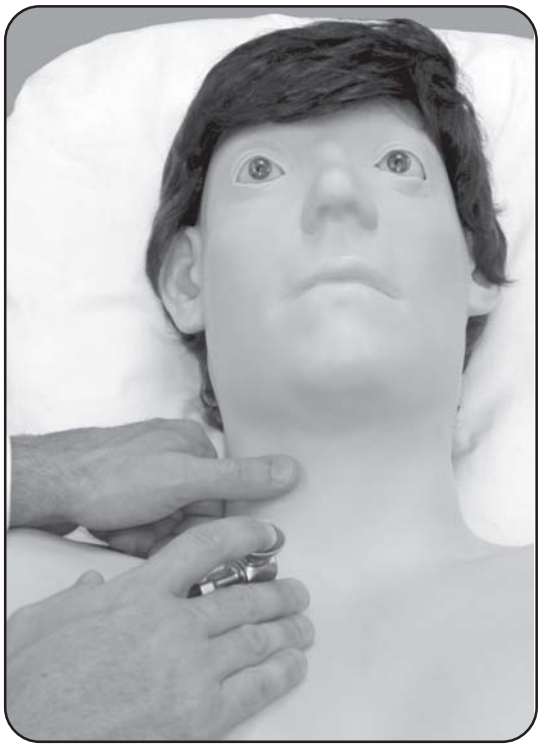


Figure 17. Auscultatory Inching while Simultaneously Palpating the Carotid Impulse for Timing

Pulmonary Auscultation

Auscultation of the lungs should also be carried out in an orderly manner. Different findings may be present on the left and right sides in the upper lung fields as well as both the lower anterior and lower posterior lung fields.

History-Taking

A built-in wireless audio system enables Harvey to function as a complete standardized patient so that learners can also practice their history-taking skills. The instructor is typically located in a nearby room, hears the questions through a separately-installed audio system, and responds through the wireless system in Harvey. Scripts for these two-way conversations with Harvey may be developed from the histories provided in Harvey's PowerPoint® or **UM**edic programs, as with any standardized patient encounter.

Demonstrating the Findings

When only one or two students are learning from Harvey, each can readily visualize, palpate or auscultate the findings. The volume of heart sounds, murmurs and breath sounds and the amplitude of impulses may be individually changed by pressing the **VOL** or **AMP** - or + as often as required. (When changing to a new disease, they will automatically return to a preset level.) When larger groups of students cluster around Harvey, or when an entire lecture room is filled with learners, techniques may be used to demonstrate and even amplify the findings so that all can share in the experience.

One simple technique is to use a cotton swab to demonstrate pulses and impulses *(Figure 18)*. If placed on the carotid artery, students may then time systole while listening through their individual headsets and may also visualize the configuration of the carotid movement. (Using a swab on the carotid is not advised when examining real patients.) The swab may also be used to demonstrate and amplify precordial movements. In addition, tangential light from a small penlight will cast shadows that help interpret the jugular venous pulse wave form. (Advise students that the venous pulse is observed, not palpated.) Finally, when teaching large numbers in an auditorium, all of this can be shared with each learner if enough headsets are available and a video camera captures the movement of the cotton swab and the image is projected on a screen.

Figure 18. Technique Using Cotton Swab to Demonstrate Pulses

Using Harvey In Different Contexts

Over many years, the question has been asked: "What population of learners is best suited for training with Harvey?" The answer is: "What population of learners is best suited for training with patients?" If a simulator validly represents a patient's findings and/or the patient encounter, then it is valid for training many learner populations. Our worldwide survey of Harvey users confirms this. The simulator is currently being used in the education of many types of healthcare professionals, at different levels of training, in different settings, in varied contexts and for different purposes.

The use of Harvey is limited more by an instructor's imagination as a teacher than by the potential of the simulator. It is the responsibility of the instructor to decide the best setting and to select the findings and/or conditions in Harvey that are best suited for training a specific population of learners.

Professions

Medical Students and Physicians

All institutions that have Harvey use the simulator for training medical students. Seventy-five percent use Harvey for training residents and 50% use it for continuing medical education.

Physician Assistant (PA) / Nurse Practitioner (NP)

More than half of these healthcare providers practice in a primary care setting. In the current era of managed care, PAs and NPs are called upon more frequently to conduct initial and follow-up physical examinations. Nearly half of the institutions that have Harvey use it to teach these populations.

Nursing

Harvey is also used at about half of the user institutions for basic and specialist training of nurses. The simulator has been used successfully to introduce nurses to the clinical examination of the cardiology patient and to a range of cardiac problems.

Other Healthcare Providers

Harvey can also contribute to the training programs of other healthcare providers. Echocardiography technicians can learn the bedside findings of the diseases they evaluate, and paramedics can learn selected findings that may be important in the acute prehospital setting. Pharmaceutical companies often request training courses that include Harvey for their representatives.

Multi-professional

The importance of teamwork in the delivery of health care is well recognized. One educational implication has been an increasing interest in the potential of multi-professional education. Not uncommonly, the facilities of Clinical Skills Centers, where Harvey may be located, are shared among medical students, nursing students and students from other healthcare professions. It is important that the different users are not seen to compete for the same resources and that this is seen as an opportunity for shared teaching. Patient management problems can be developed with Harvey as a focus, and these can be tackled by a multi-professional group of students or trainees. This application of Harvey is currently underused.

Levels of Education

All user institutions utilize Harvey to train medical students in the later "clinical" years of their medical school curriculum. The simulator is also used at 75% of these institutions during both physical diagnosis courses in the early medical student curriculum and early postgraduate training. The experiences reflected in our worldwide survey demonstrate that Harvey can be used at any level of medical education.

Early Medical School Training

Harvey and the UMedic system can be used throughout the early phases of the curriculum to enrich discussions of the basic sciences. A normal "patient" can be examined and the findings correlated with normal anatomy and cardiovascular hemodynamics. An example of a patient with abnormal auscultatory events might then be added with a review of the associated pathophysiology.

A clinical example with a problem-based learning approach can also be used, so that the students can see what is expected of them in the context of medical practice. A cardiac problem such as myocardial infarction can be used as an example. The learning can be made more meaningful for the student if Harvey and the UMedic programs are used to illustrate the clinical problem.

Harvey can be used to emphasize vertical integration in the curriculum and the continuum of students' learning. Students are introduced to basic skills in the early years and, as they progress through their medical school and postgraduate training, they:

- increase the breadth of their competence by learning new skills (e.g., relating to congenital heart disease)
- increase the level of difficulty through exposure to more complex situations (such as multiple valvular lesions, or less obvious or typical auscultatory findings)
- increase their proficiency (with fewer errors expected, and examination of the patient completed in less time)

Later Years of Medical School Curriculum

Harvey can be used to assist students to learn clinical skills in cardiology and to strengthen their understanding of the relevant pathophysiology. Harvey is not a replacement for contact with real patients, but can greatly enhance the value of time spent in the clinical context and the overall acquisition by the student of the required competencies. In many centers, Harvey plays a key role in the clinical rotations by reinforcing bedside findings elicited from real cases seen on the wards and in ambulatory care settings. When used with the associated slide programs and/or UMedic, students also demonstrate significant gains in their cognitive knowledge and management skills.

Postgraduate Training

Harvey is of value both for general postgraduate and for specialist cardiology training. In generalist training, Harvey can help postgraduate trainees to learn and/or maintain their basic auscultatory skills. It can also be used to develop additional skills and understanding relating to more specialized cardiac practice. For example, cardiology fellows must be able to assess the severity of a valvular lesion based on the bedside findings.

At the University of Miami, 2nd- and 3rd-year internal medicine residents have a dedicated teaching ward rotation in which they spend 10 hours over a 4-week period focusing on their cardiology clinical skills. It has been our experience that when residents are taking care of patients in the hospital setting, their focus and time to practice bedside skills on Harvey are limited.

Continuing Education

Maintaining competence is a continuing challenge facing medical education. The acquisition and retention of basic cardiac bedside skills are becoming requirements of certification organizations; e.g., the American Board of Internal Medicine has emphasized these skills in the Clinical Skills Multimedia Self-Evaluation Process module of its Continuous Professional Development Program.[15]

Harvey provides a convenient and attractive resource for "refresher" courses for family physicians and hospitalists. If you use it for this purpose, you will find that physicians value the experience and feel that they gain much needed competence and confidence in their auscultatory abilities.

Harvey can be used as a resource for short Continuing Medical Education courses, much like "grand rounds." A clinical case is presented and the findings demonstrated on Harvey, with the pathophysiologic mechanisms and investigations discussed and explained using the UMedic system. Alternative diagnoses with their associated clinical findings can also be demonstrated on Harvey and with the UMedic system.

EXAMPLES OF THE USE OF HARVEY FOR CONTINUING EDUCATION

COURSE	AUDIENCE
University of Miami Annual Teaching Conference in Clinical Cardiology and Neurology	Primary Care Physicians, Nurses, Nurse Practitioners and Physician Assistants
American College of Cardiology Heart House	Nurses, Nurse Practitioners and Physician Assistants
American College of Osteopathic Internists Annual Convention and Scientific Sessions	Osteopathic Internists
Society for General Internal Medicine Annual Meeting	Academic Internists
Association of Physician Assistant Programs Annual Meeting	Physician Assistant Program Directors and Practitioners
Association for Medical Education in Europe Annual Conference	Practicing Physicians and Medical Educators
American Academy of Family Physicians Annual Scientific Sessions	Family Physicians
American College of Physicians Annual Session and Postgraduate Courses	Internists
American Heart Association Annual Scientific Sessions	Cardiologists, Internists and Nurses
Association of American Medical Colleges Annual Meeting	Clerkship Directors

Settings

Harvey teaches best when used in a variety of learning environments. The following summarizes several very effective settings.

Instructor Teaching

While students learn from Harvey with no teacher, we recommend that the initial session is carried out by the instructor. This allows an appropriate orientation and the opportunity for the teacher to express his or her curricular goals and describe the technique of the bedside examination firsthand. We also recommend that additional instructor teaching sessions are scheduled during the course to cover additional disease states and answer questions on those cases studied by students during their self-learning sessions.

Small Group Instructor Teaching (Harvey Bedside Rounds)

This is the simplest system for instructor teaching *(Figure 19).* All you need is enough headsets for each of the students when they cluster around Harvey as they would a real patient. The instructor should prepare by reviewing the description of the condition in the *Harvey Learner Manual* that he or she plans to cover during the session. Most elect to start with the normal patient. The instructor will be able to assess the background level of skills and the needs of the students during this interactive session and provide focused teaching. Because these sessions are hands-on and interactive, students maintain a very high level of interest for up to two hours.

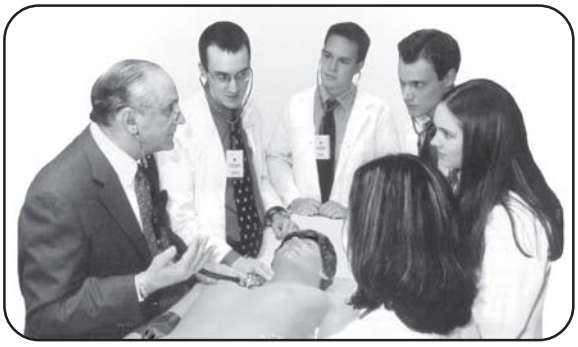


Figure 19. Instructor using Harvey in small group session with 4th-year medical students

Large Group Instructor Teaching (Auditorium / Lecture Hall)

This is a powerful method to reach many learners at one time. It also requires additional equipment and a bit of practice by the instructor to demonstrate the findings so that all may share the bedside findings. Harvey is being used very successfully at medical schools to teach entire classes and at conferences to teach hundreds of learners *(Figure 20).* Although this format prevents the learner from having direct contact with Harvey during the session, the use of individual infrared or FM headphones for cardiac auscultation and a video camera and projector for visualization of pulses allows each person to participate in the evaluation of the non-auscultatory and auscultatory physical findings. In this way, skillful teachers can incorporate specific clinical findings into lectures on various topics including anatomy, pathophysiology, clinical diagnosis and patient management.

Figure 20. Instructor using Harvey in large lecture setting

Large group teaching need not be a passive learning experience. In a traditional lecture, the audience assumes a purely passive role and concentration falls off after 20 to 30 minutes, with most people able to recall around three facts from an hour-long lecture. We have found the use of a *computerized audience response system* to be a very effective means to transform large group teaching sessions into active learning experiences leading to more efficient acquisition and retention of knowledge.

Audience Response System[16]

Multiple choice questions are posed on slides and the audience is asked to anonymously enter an answer on individual keypads. The results are automatically tallied and displayed. The immediate feedback stimulates teacher-student focus and discussion.

Independent Student Self-Learning (Individual and Small Group)

Most learning with Harvey falls into this category. Independent learning makes a very important contribution to a user's hands-on skills training *(Figure 21).* Students master the area being studied, while at the same time they develop the ability to work on their own and to take responsibility for their own learning. Because learners can proceed at their own pace, it provides an excellent means for "deliberate practice" of bedside skills. The associated learning materials, especially UMedic, effectively substitute for a personal instructor. Small groups can function in a similar way. There is less individual hands-on time, but there is the opportunity to exchange ideas and solve problems together.

Figure 21. Independent learning with Harvey

Deliberate practice has been defined as the "opportunity for an individual to tackle a well defined task with appropriate difficulty for that individual, receive informative feedback and have opportunities for repetition and correction of errors."[17]

Students Teaching Students

One of the students is trained and prepares in advance, assumes the role of the instructor, reviews key findings, and acts as the facilitator during the session *(Figure 22).* The University of Miami has implemented an Academic Societies program in which senior medical students use Harvey to provide instruction and feedback to 1st-year medical students on the fundamentals of the cardiac bedside exam. We find this system to be very exciting. The student-teachers are highly motivated and can become quite skillful. They save instructor time and serve as role models for the students they teach. We plan to expand this program, recognizing instructor time must also be invested in training and monitoring the performance of the student-teacher.

Figure 22. A student teaching students with Harvey

Integrating Harvey into the Curriculum

Practical Issues

Harvey must be made an integral part of the required curriculum. If it is an optional resource, students have much less incentive to use the simulator. Outcomes must also be assessed, as medical education is driven by testing.

Planning

The first step is to plan the initial experience with Harvey in a part of the curriculum that is easy for the Harvey "champion" to control. Examples include champions that are the Directors of the Cardiology Elective, the Clinical Skills Center or the Physical Diagnosis Course. To integrate Harvey throughout the entire curriculum will take cooperation among multiple faculty members. It will require leadership and a willingness to change by all involved. All planning must include specific learning goals and the testing of outcomes.

Inclusion in a Timetable

Develop a timetable for the use of Harvey in different settings throughout the curriculum. This should include instructor-facilitated small group sessions and independent self-learning sessions. Harvey is ideally first introduced to an entire class by an instructor in an auditorium/lecture hall setting. An example of an effective timetable is shown below:

Plan to Utilize Harvey in a 4-year Medical School Curriculum

Learning Goals	Course	Modules	Method	Time
Year 1 Normal cardiovascular physiology & bedside examination	Physiology and/or Early Clinical Skills	Normal (46) Normal (46)	Large Group Lecture Setting Small Group / Independent Learning	1.5 hours 1.5 hours
Year 2 Review normal and add classic valve lesions: pathophysiology & bedside examination	Pathophysiology and/or Advanced Clinical Skills (Physical Diagnosis Course)	Review Normal (46) Highlight MR (7), AS (13), AR (17), MS (4) MR, AS, AR, MS	Large Group Lecture Setting Small Group / Independent Learning	2 hours 6 hours
Year 3 Review common diseases, including the bedside examination, laboratory evaluation & treatment	Medicine Clerkship	Angina Pectoris (39) Inferior Infarction (40) Anterior Infarction (43) Hypertension (36) Cardiomyopathy (42)	Small Group / Independent Learning	7.5 hours
Year 4 Comprehensive review of cardiovascular curriculum	Adult and/or Pediatric Electives	Review previous modules Add additional congenital and acquired disease modules	Small Group / Independent Learning	15-20 hrs. in 4-week elective

MR = mitral regurgitation, AS = aortic stenosis, AR = aortic regurgitation, MS = mitral stenosis

Student Orientation and Assistance

Provide students with an orientation on the use of Harvey. This is a simple secretarial task carried out with small groups of learners at Harvey's bedside. Students may also be helped by providing appropriate study guides.[18] The Harvey Learner Manual includes information on orienting learners and serves as a study guide.

Faculty / Staff Development

The first step is for the Harvey "champion" to carefully review this guide and the Harvey Learner Manual. If you have UMedic, the next step is to review the Bedside Findings section of several UMedic programs. Start with normal and review at least 2 valve lesions such as aortic stenosis and mitral regurgitation. This will show you how an academic cardiologist with 30 years of experience teaching with Harvey demonstrates and explains the findings. The last step is to go to Harvey's bedside and "try out" the simulator with the Harvey Learner Manual in hand. Review whatever condition you wish and consult the manual for the explanation of the findings along with a graphic representation of each finding.

Once Harvey's "champion" has carried out the above, he or she can readily guide other faculty along the same route and ask the staff to review those sections of this guide that are pertinent for them. Once an instructor has had some experience teaching with Harvey, a very effective way of training another instructor is for that person to observe the more experienced teacher. Each will ultimately develop their own techniques and will learn from each other.

While Harvey is most often taught from a case-based approach, the simulator is often used to teach from a "bedside finding" perspective. In this case, the instructor might start with the arterial pulses and proceed to venous pulses, precordial impulses, heart sounds, murmurs and breath sounds. A brief outline of this approach, as implemented at one user institution, is found in Appendix B. There is also a glossary of pulses, impulses and acoustic events found in the Harvey Learner Manual that will help teach the "bedside finding" approach.

Finally, if you want to reach a large audience of your colleagues and potential instructors, consider a presentation at Grand Rounds. If you stimulate much interest, it will keep you busy in the short term, but could provide you with a cadre of teachers in the long term. Also do not forget that teaching trainees, including senior students, to teach their junior colleagues is an effective way to stimulate interest and develop additional instructors.

Curriculum Evaluation

Evaluation of the use of Harvey should be included as part of the standard curriculum evaluation. Review how Harvey is used in the program and make adjustments as necessary. Students themselves may come up with ideas for using Harvey.

Different Approaches

Our experience, user surveys and studies reveal that Harvey is being used with a wide variety of educational approaches.

Small Group Instructor Teaching

This approach is employed at nearly 100% of institutions using Harvey. About half of the user institutions also carry out large group interactive teaching. While teacher-centered learning is a valuable educational method, it is most effective when combined with student self-learning.

> At most schools, an instructor introduces the bedside examination, orients students and provides questions to stimulate further learning. Students then practice on their own to develop and hone their clinical skills using Harvey for "deliberate practice."

Student Self-Learning

This approach is utilized by nearly 70% of institutions using Harvey. The companion self-assessment slide programs and the interactive UMedic system facilitate student self-learning and reduce the need for instructor time.

Case-based

The self-assessment slides and UMedic system provide a traditional case-based approach to learning, where information is given in a step-wise fashion as the student progresses through the case. This system is adopted at most user institutions.

Problem-based / Task-based

Harvey is also used with a problem- or task-based approach, in which the learner approaches the "patient" with a problem (heart murmur, chest pain) rather than a diagnosis (mitral regurgitation, acute pericarditis).

Integrated

Vertical Integration

This approach ensures that students build new competencies on existing capabilities. For example, the "third heart sound" is visited several times throughout the curriculum:

- during the normal physiology course
- during a cardiac pathophysiology section
- during a clinical skills course on auscultation
- during a medicine clerkship as a sign of a patient in heart failure on suboptimal or ineffective medical therapy

Horizontal Integration

This approach ensures that students recognize the relationship of the topic in one discipline to the same topic in another discipline. For instance, the presence of a heart murmur can serve as a focus for the integration of medical, surgical, pediatric, obstetric and psychological perspectives as students rotate through a range of clinical clerkships.

Inter-professional

An inter-professional perspective can be provided by participation of different members of the healthcare team (including physicians, nurses and paramedics) through joint learning in a centralized clinical skills center.

Community-based *versus* Hospital-based

As a result of increased patient turnover and decreased inpatient stays, the focus for student learning has shifted away from the teaching hospital environment to the community and ambulatory settings where students now gain their clinical experience.

Harvey's 30-disease curriculum and the UMedic programs provide a wide variety of conditions that may be encountered either in the hospital or community setting. Usually, the demands of taking care of acutely ill hospitalized patients limit the amount of thoughtful, deliberate use of the simulator that may be more feasible when caring for patients in an ambulatory setting.

Adaptive Learning

At several institutions, students can take a special elective to provide additional "tailor-made" learning opportunities. In such an adaptive curriculum, students spend different amounts of time studying a program or module depending on their needs. This is accomplished by pretesting all students prior to the course to assess their strengths and weaknesses, so that their independent learning time can be structured around their deficiencies. The student's mastery of skills is assessed halfway through the course, feedback is given, and further studies are organized to meet the student's needs. For example, the "Bedside-Only" option of the UMedic system allows learners to focus on physical exam skills in Harvey, rather than spending unnecessary time on sections covering diagnostic testing.

Systematic

The standardized curriculum in Harvey, coupled with specific learning goals, ensures that students systematically address relevant clinical topics in cardiology. The built-in administrative program in UMedic can record time spent on the programs. This record can be reviewed to see if there are any gaps or redundancies in the students' experiences.

Range of Learning Outcomes

In recent years, there has been a growing movement toward outcomes-based education.[19-23] This is a performance-based approach where the emphasis is on the product (in this case, what sort of practitioner will be produced), rather than on the educational process. Harvey has been shown to be a useful tool in aiding educators and students in the teaching and assessing of outcomes.

Our survey of users revealed the following outcomes in which Harvey contributes to learning:

Physical Examination Skills

Harvey is used at all institutions to teach the fundamentals of the cardiac physical examination and to provide the opportunity for repetitive practice.

Patient Investigation & Management

Harvey's clinical findings can be combined with discussions that address diagnostic reasoning, differential diagnosis and the management of the condition suggested by the findings. This approach is being used by some medical teachers in an iterative process that allows immediate reprogramming of Harvey to provide a different set of "what if" clinical findings, thereby extending the discussion to other diagnostic and management possibilities.

Communication Skills

Harvey is used in combination with standardized patient scenarios. The learner takes a history from a standardized patient (or through Harvey's built-in audio system), then examines Harvey (who has findings consistent with the patient presentation) and, finally, verbally communicates the findings and their meaning to either the patient or facilitator.

Understanding of Basic Science in Clinical Medicine

Harvey has also been shown to be a powerful tool in teaching and reinforcing knowledge and understanding of anatomy and pathophysiology. It allows on-demand access to a wide variety of individual clinical findings and/or patterns of physical findings in specific conditions that may be followed by review of the underlying pathophysiology.

Appropriate Attitudes and Ethical Understanding

Harvey is also being used to frame discussions that relate specific findings to choosing appropriate cost-effective laboratory and imaging investigations. This approach has significant potential to encourage trainees to consider the human and societal costs of unnecessary investigations and inappropriate treatments throughout their training and in their practices.

Clinical Reasoning and Appropriate Decision Making

Harvey has often been used in conferences to present cases that lead to discussions of management by experienced cardiologists and cardiac surgeons. The audience first becomes involved with the case by sharing the bedside findings and formulating their own diagnosis. They further benefit from the reasoning and decisions made by the experienced experts.

Lifelong Learning

Harvey provides an opportunity for clinicians to learn and review bedside skills by intermittent repetitive practice. This is necessary to maintain skills, especially those required to recognize uncommon cardiac conditions.

Using Harvey As An Assessment Tool

Harvey is an excellent tool for testing bedside cardiovascular examination skills. It is an ideal "standardized patient" for assessment. Patient findings can be presented uniformly and the process of skills testing can then be made objective.

Harvey is used for formative assessment to monitor a student's progress through a course or a phase of their studies. It is also used for summative assessment at the end of different courses, as it meets the fairness criteria that all can be tested on the same materials and judged by the same standards.

In a multicenter study sponsored by the National Heart Lung and Blood Institute[24], the standardization inherent in Harvey provided improved sampling of student performance, as any area (e.g., vital signs, non-auscultatory events, auscultation, etc.) could be assessed.

Testing Procedure

There is a simple procedure that allows instructors to examine learners without their knowing the disease code. The disease is called up by the instructor in the usual manner. The instructor then presses **C,** and the code number disappears. (Do not enter another disease code number or press **OK**.)

What Should Be Assessed and How

Harvey has been used as an assessment tool in many different ways. Important examples include the following:

The Entire Cardiac Examination

This comprehensive assessment system was developed as part of an NHLBI sponsored multicenter study.[24] More than 200 students from 5 medical schools participated, with about half in the control group. The skills examination covered all significant aspects of the bedside cardiac examination. Major categories were vital signs, jugular venous pulses, carotid and peripheral arterial pulses, precordial movement, auscultation and diagnostic impression. Immediately after each student individually examined a randomly selected disease in Harvey and a real patient with a defined disease, he or she filled out an answer sheet by circling the graphic finding that best represented what they visualized, palpated or heard on auscultation. Students trained on Harvey demonstrated a highly significant gain in the posttests involving Harvey and real patients compared with students trained only on patients with no exposure to Harvey. This type of individual testing is time consuming, but it has high validity and is very effective.

Auscultation Only

This testing system focuses on the most important auscultatory findings. The findings chosen were judged by program directors of internal medicine and family medicine residencies to be extremely important, and therefore they should be mastered by a practicing physician.[4] Our consortium of cardiologists reviewed their decisions and agreed. The findings include:

Important Auscultatory Findings	
2nd Sound Splitting	Aortic Stenosis
Third Sound	Aortic Regurgitation
Fourth Sound	Mitral Stenosis
Systolic Clicks	Continuous Murmur
Innocent Murmur	Tricuspid Regurgitation
Mitral Regurgitation	Pericardial Rub

This test is most often carried out in a large group setting. The disease that has the desired auscultatory finding in Harvey is called up. All auscultate through headsets and then choose the answer from a list that includes the 12 findings. After exposure to Harvey, a highly significant gain in skills is observed.

Bedside Findings Based on Skill Level

We have also developed a series of questions for different bedside findings based on the expected level of the learner's skills. The following table uses the example of a fourth heart sound to demonstrate how the finding may be tested at different levels:

Harvey is set so that a fourth heart sound (S4) is present at the apex.

Difficulty / Learner Level	Variable Tested	Correct Answer
1 - 1st year medical student	Identify finding	Fourth heart sound
2 - 2nd year medical student	Identify finding and correlate it with underlying pathophysiology	Fourth heart sound - reduced left ventricular compliance
3 - 3rd/4th year medical student	Identify finding and correlate it with its underlying disease process and differential diagnosis	Fourth heart sound - hypertension, aortic stenosis, hypertrophic cardiomyopathy
4 - House Officer	Identify finding and correlate with the severity of the underlying disease process and management	Fourth heart sound - its presence in a "young" patient with aortic stenosis denotes severe disease and suggests the need for surgery

Sample multiple choice questions for levels 1 and 2 are shown below:

Choose the *best* description of the acoustic events heard at the apex.

a. S1 + S2 + Third heart sound (S3)
b. Fourth heart sound (S4) + S1 +S2 *(correct)*
c. S1 + ejection sound + S2
d. S1 + S2+ mid diastolic murmur
e. S1 + systolic click + S2

Which one of the following is *most* likely associated with the acoustic events at the apex?

a. Right ventricular dilatation
b. Mitral valve narrowing
c. Left atrial enlargement
d. Left ventricular hypertrophy (*correct)*
e. Right ventricular hypertrophy

The MIAMI group has developed a comprehensive cardiology bedside skills assessment instrument as part of a computer-based testing system. A rigid 8-step procedure was followed.[25] This resulted in two sets of examinations, each with 25 questions that have high reliability coefficients (KR 20) of .81 and .84. These testing instruments may be used to assess the gain in skills after exposure to Harvey and/or UMedic.

Self-Assessment

A system of self-assessment is an integral part of the Harvey teaching system. Interactive questions are embedded into the slide programs and the UMedic system. They provide instant feedback for the learner. This system is highly developed in the UMedic programs, where wrong answers result in mandatory remediation with an explanation of why the answer was wrong and an explanation of the right answer. If the answer is correct, further explanation is optional. In addition, the UMedic system automatically grades each learner's performance, advises the learner what areas to review further, and provides the learner with a record of his or her performance. The instructor is provided with records of both individual and group performance for all categories of learners.

Objective Structured Clinical Examinations (OSCEs)[26]

Harvey has also been integrated into OSCE stations covering the cardiovascular system using multiple choice questions, short answer questions and checklists. Several stations, including one with Harvey, may be structured around a "problem of the week," with a series of linked stations testing a range of learning outcomes.

Examples of individual stations during a week in which the problem is atherosclerotic disease include:

1. examination of the leg in a patient with peripheral vascular disease
2. auscultation of a fourth heart sound and mitral regurgitation due to papillary muscle dysfunction in a patient with a myocardial infarction programmed in Harvey
3. telephone conversation with a simulated patient with chest pain
4. advice to a simulated patient and his wife on discharge from the hospital following a myocardial infarction

Portfolios[27]

Students may collect a portfolio of evidence of their mastery of the appropriate learning outcomes from a variety of sources. These may be in the form of a printout from the UMedic program that documents learner use, or a logbook documenting the conditions examined and physical findings encountered during their exposure to Harvey *(Appendix C* provides a checklist from one institution to document the normal examination*).*

Choosing the Appropriate Assessment Instrument

This is an individual decision. A variety of factors should be considered, including:

What you wish to test

- the entire examination for one or more conditions
- a component of the examination such as auscultation

What level of complexity you wish to test

- identify a finding
- explain its pathophysiology
- decide the patient's management

What environment you wish to use

- individual
- in small or large groups
- as part of an OSCE

How you wish to test

- written or computer-based
- multiple choice questions or choosing the graphic representation of the finding
- observing the learner and using a checklist

Other considerations include:

- the validity and reliability of the assessment instrument
- the feasibility in terms of time and resources

A word of caution: while you absolutely must test your students, it takes a long time and some expertise to construct testing instruments that are valid and reliable, and to test each student individually by observation of their hands-on skills. You should first consider the advantages of systems that are easily administered and automatically graded. You might begin by:

- testing the most important findings
- in the most pertinent conditions
- at a basic level of difficulty
- in a group setting
- using an instrument that can be graded automatically

Using Harvey In Research

Previous Studies

Many descriptive, review, and research articles have been published over the past 30 years demonstrating Harvey's utility in developing and carrying out educational studies. This table gives details of 26 published articles in which Harvey was used.

Ref. #	Published	Type	Subjects	Group Size	Variable(s) Described / Studied
28	1974	Descriptive	N/A	-----	Harvey's (H) development
29	1980	Research	MS4	23	Bedside skills / "H" effectiveness
30	1980	Descriptive	MS4, MD	770	"H" development / user satisfaction
31	1980	Descriptive	N/A	-----	"H" development / use
32	1981	Research	MD	800	User satisfaction
33	1986	Review	N/A	-----	"H" use
34	1987	Research	MS2	203	Bedside skills, "H" effectiveness
24	1987	Research	MS4	208	Bedside skills, "H" effectiveness
35	1988	Review	N/A	-----	"H" use
36	1990	Descriptive	N/A	-----	"H" use
37	1991	Review	N/A	-----	"H" use
38	1992	Research	Int Res	63	Bedside skills
39	1993	Research	Int Res	56	Bedside skills / "H" effectiveness
40	1995	Review	N/A	-----	"H" use
41	1995	Research	Int Res	6	Bedside skills
42	1997	Review	N/A	-----	"H" use
43	1997	Research	EM Res, MD	46	Bedside skills
44	1999	Review	N/A.	-----	"H" use
45	1999	Review	N/A	-----	"H" use
46	1999	Review	N/A	-----	"H" use
47	2000	Research	Ped Res	47	Bedside skills
48	2000	Review	N/A	-----	"H" use *(in Spanish)*
49	2000	Research	PA	53	Bedside skills / User satisfaction
50	2001	Review	N/A	-----	"H" use
51	2001	Research	EM Res, MD	39	Bedside skills
52	2001	Review	N/A	-----	"H" use
53	2003	Descriptive	MS	-----	"H" use
54	2003	Research	DO	64	Bedside skills

Codes for Subjects are:

N/A:	not applicable	Ped Res:	Pediatric residents	MS( ):	Medical Students
Int Res:	Internal medicine residents	MD:	Practicing Physicians		(Year in parenthesis)
EM Res:	Emergency medicine residents	PA:	Physician assistants	DO:	Doctor of Osteopathy

Further Areas of Research

Harvey has the potential to contribute to further educational research for a variety of populations, including the many types of learners that are currently taught with or using the simulator. Research may focus on Harvey as an educational intervention or as an evaluation tool. Examples of the types of questions that could be answered by further research are found below.

Harvey as an Educational Intervention

Progressive development – sequential use of Harvey for development of progressive knowledge and skills

- What is the cumulative benefit of using Harvey throughout a medical school curriculum?

Quantitative Practice - amount of practice necessary to achieve an enduring level of performance

- How often do different learners need "refresher" experiences to maintain an expected level of performance?

Problem-based Learning

- How can Harvey best be used as part of the "problem presentation"?

Faculty Development – use to train young faculty and house officers to improve their bedside teaching skills

- How much practice is needed to transfer these skills to actual patient settings?

Harvey as an Evaluation Tool

- What is the quality of data obtained from Harvey compared to other sources used to evaluate the performance of learners at the end of a period of training?

- What is the value of using Harvey for educational screening (e.g., as a test to determine if students require remediation in physical diagnosis or can proceed to a clinical elective)?

- What is the cost of using Harvey for training compared to standardized patients and real patients?

Use in Public Relations

Harvey may also be used in Public Relations. The press, the public, and potential Harvey learners are captivated by the concept and sight of a body lying before them that has pulses and impulses and heart sounds and actually breathes. A common request is to call up a condition that has been diagnosed in themselves or a loved one. As a result, Harvey has been used to generate publicity, to attract funding, and to demonstrate to potential recruits.

Publicity

The introduction of Harvey at a medical institution is often a high profile activity that attracts the interest of the press. Numerous newspaper articles have been written over the years, ranging from *The New York Times* to *The London Sunday Times*. Television coverage has also been extensive, ranging from U.S. and European News to National Geographic and "That's Incredible."

Fund-raising

Harvey may be used to generate interest from foundations, private donors and government agencies to donate or provide funding for projects related to medical education and the use of simulation.

Recruitment

Harvey is often used as a recruitment tool for prospective students and house officers as an example of the institution's commitment to adopt innovations in medical education and skills training.

Misconceptions About Simulators and Harvey

This used to be a big problem. Thirty years ago there were few believers; today there are many. This assertion is supported by a striking increase in the establishment of Clinical Skills and Simulation Centers at many medical centers and the marked increase in demand for simulators, including Harvey, over the last several years.

What follows may seem like "preaching to the choir." If you have Harvey, you are clearly a believer. It is likely there will be some at your institution who are not. Doubters are produced primarily from inherent resistance to change. Other factors, such as skepticism about the use of technology, are much less important today. Integrating Harvey into the entire curriculum will likely require teamwork with several faculty colleagues. To help Harvey's "champion" answer questions that may arise, some misconceptions related to simulators and Harvey are addressed below.

Misconception 1 Cardiology bedside skills are no longer important

NO Studies have shown that the bedside examination of cardiac patients is accurate and cost-effective.[2,3] There has been a trend toward less frequent teaching of clinical skills, but this has occurred as a result of decreased faculty time for instruction rather than an opinion that these skills were unimportant.[4,5]

This trend is changing. The Medical School Objectives Project (MSOP), sponsored by the Association of American Medical Colleges, lists the ability to perform both a complete and organ-specific physical examination as one of the primary attributes that a physician must possess.[55] The Physical Examination Self-Evaluation Process committee of the American Board of Internal Medicine shares this view.[15] The committee has developed a multimedia computer-based self-assessment program to reaffirm the importance of physical diagnosis as a competence in internal medicine. The addition of the "talking" feature makes Harvey an excellent training system for the USMLE Step IIb examination.

The cardiology bedside exam is extremely important, even in this era of high technology testing. Carefully performed, it may obviate the need for costly imaging or it may complement and clarify the results of indicated studies.

Misconception 2 Harvey is a substitute for patient-centered clinical teaching

NO Nothing is better than real patients, and Harvey is absolutely not intended to take the place of real patients. Harvey, however, does address the serious drawbacks inherent in a totally patient-dependent curriculum:

- the unavailability of patients demonstrating certain findings at specific times in the curriculum schedule
- the shorter in-patient stays for hospitalized patients who are also less frequently in their room (often undergoing diagnostic testing)
- the inconvenience and stress to patients

"Harvey is a wonderful instrument to teach heart sounds. Since patients are in and out of hospitals so rapidly, now students can hear the sounds and murmurs at any time."
Orlando Medical Center

"There is a huge increase in what can be achieved in 1 hour of teaching with Harvey compared with 1 hour of patients."
King's College, London

"We like the enhanced diversity of different heart sounds."
University of Essen

"We can reproduce multiple disease states within minutes - very time efficient."
Bayfront Medical Center

Clinical teaching that stresses "follow me" on rounds is not enough. It must be complemented by methods that standardize the curriculum and provide skills training through simulation.

Misconception 3 There is no proof that the skills learned on Harvey transfer to patients

NO Harvey has been rigorously tested to establish its educational efficacy. In a multicenter trial, sponsored by the NHLBI,[24] involving 208 senior medical students at 5 institutions, fourth-year students who used Harvey during their cardiology elective performed significantly better than the non-Harvey trained group, who learned in the traditional manner from patients. This was true not only on the Harvey skills posttest, *but also on the real patient skills posttest.*

Misconception 4 The findings in Harvey are too perfect

NO That is the whole idea. One of the primary benefits of using simulation is to remove the "background" noise (noisy room, sick or uncooperative patient) that is often present when examining real patients, so that fundamental skills of palpation and auscultation may be learned, practiced and honed. Studies have also demonstrated that those who are better able to interpret findings on Harvey are better at interpreting those same findings on real patients.[24,34] Students will learn over time of the unlimited "imperfect" variations found in real patients.

Benefits of Medical Simulation[56]

- Safe environment that is mistake forgiving
- Trainee focused vs. patient focused
- Controlled, structured, proactive learning
- Reproducible, standardized, objective
- ↑ public trust in profession

"If you cannot master the findings on Harvey - you will never be able to master them with real patients."

Emory University

Misconception 5 Harvey can only teach clinical skills

NO Harvey has been used as a tool to address several learning outcomes in addition to clinical skills. In the multicenter NHLBI study, students trained with Harvey also performed significantly better on cognitive exams than non-Harvey trained students.

In addition, Harvey has been used as a tool to *assess* clinical skills. Examples are cited in several published studies involving 2nd-year and 4th-year medical students, residents in internal medicine, pediatrics and emergency medicine.[24,29,34,38,39,41,43,47,49,51]

"This is the best way for 1st-year students to understand mechanical events of the cardiac cycle."

University of Florida

"Increases knowledge of clinical pathophysiology."

University of South Florida

"All 3rd-year students have to pass a patient simulation test on Harvey in order to pass the medicine clerkship."

Penn State University

Misconception 6 The use of Harvey makes learners less humane

NO The NHLBI study specifically addressed this issue.[24] Patients, who were blinded as to which group of students trained on Harvey and which group did not, perceived no difference between the groups. Combining simulation technology with traditional patient-centered teaching results in more confidence in the "laying on of hands" at the bedside, thus emphasizing the personal physician-patient relationship.

Misconception 7 Harvey will require more teaching time

NO The opposite is true. While not a substitute for an experienced teaching clinician, the self-assessment slide programs and/or UMedic system facilitate self-learning. They sequentially guide the learner through each case and conclude with a summary of the disease and review of the case.

In studies that have documented the effectiveness of Harvey as a teaching tool, the majority of student exposure to the simulator was in the form of small group self-learning sessions without an instructor.[24,34]

On the other hand, Harvey does need a faculty "champion" who both organizes the use of the simulator and spends time teaching with Harvey. Nothing is better than this role model teacher mentoring his or her students at Harvey's bedside. That person will also have to spend time training other faculty, but that usually takes only an hour or two. All of Harvey's "champions" enjoy the role!

"Our students benefit from the independent learning experience without having to depend on faculty for instruction."
New York Medical College

"Independent study sessions have given our students the opportunity to practice."
Univ. of California-Los Angeles

"We have used senior medical students to serve as mentors to 1st-year students during their Introduction to Clinical Skills Course."
University of Miami

Misconception 8 Harvey has a limited role in the curriculum

NO This guide has provided numerous examples suggesting how Harvey may be fully integrated throughout the curriculum at multiple levels and for multiple populations of learners. Our survey revealed the following regarding those schools who were most successful at integrating Harvey into the curriculum:

- The average class size was 150 students
- Harvey was used during 2nd, 3rd, and 4th years: during second and third years for the entire class and during the senior year in a cardiology elective (20-80% of the class)
- When all 3 class years were in session, the simulator was used an average of 22 hours per week to teach medical students
- The majority of training (17 h/wk) was carried out in small groups in a self-learning mode while the remaining time (5 h/wk) involved instructors teaching with Harvey

The comprehensive curricular plan that has evolved from our experience and the survey of Harvey users should further stimulate the use of the simulator throughout the entire curriculum.

Misconception 9 Harvey is not a cost-effective learning tool

NO The cost-effectiveness of Harvey results from its effectiveness in teaching bedside skills to so many different populations and levels of learners - many hundreds each year at a typical medical center. In addition, most of the hands-on self-learning hours spent on the simulator represent what in the past was possible only through teacher-student time at the bedside, and can be interpreted as time saved by the instructor. Faculty time is also saved by not having to identify patients with a variety of bedside findings and locate diagnostic studies that are presented in Harvey's software programs.

"The self-assessment learning programs allow one to target faculty instruction time to other areas."
Duke University

"The use of Harvey frees faculty time."
Emory University

"The organization of learning sessions is not time consuming - everything is already there."
University of Essen

The initial investment in Harvey compares very favorably to a faculty member's salary, and it is non-recurring and requires no benefits. Because Harvey is very reliable over many years, there is also little cost for maintenance.

Conclusion

We hope this guide has served its purpose: to provide users of Harvey an outline for its optimal use at their institution. New technology and the changing medical education environment are likely to ensure that the use of simulation will continue to increase. The task for medical educators will be to embrace and harness this modality's potential and use it to enhance the self-directed acquisition of skills throughout the lifelong medical education continuum.

References

1. Issenberg SB, Petrusa ER, McGaghie WC, et al, Effectiveness of a computer-based system to teach bedside cardiology. *Acad. Med.* 1999;74(Suppl.):S93-95.

2. Roldan CA, Shively BK, Crawford MH. Value of the cardiovascular physical examination for detecting valvular heart disease in asymptomatic subjects. *Am J of Card.* 1996; 77: 1327-1331.

3. Danford DA, Nasir A, Gumbiner C. Cost assessment of the evaluation of heart murmurs in children. *Pediatrics* 1993;91:365-368.

4. Mangione S, Nieman LZ, Gracely E, Kaye D. The teaching and practice of cardiac auscultation during internal medicine and cardiology training: a nationwide survey. *Ann Intern Med.*1993;119: 47-54.

5. Mangione S, Nieman LZ. Cardiac auscultatory skills of internal medicine and family practice trainees: a comparison of diagnostic proficiency (published erratum appears in *J.A.M.A.*1998;279:1444). *J.A.M.A.*1997;278:717-722.

6. Garrison P. Flying without wings. *A Flight Simulation Manual.* Blue Ridge Summit, PA:TAB Books, Inc., 1985, 1-31, 102-06.

7. Goodman W. The world of civil simulators. *Flight International Magazine*. 1978;18: 435.

8. Rolfe JM, Staples KJ. *Flight Simulation.* Cambridge: Cambridge University Press. 230-250.

9. Ressler EK, Armstrong JE, Forsythe GB. Military mission rehearsal: from sandtable to virtual reality. In: A Tekian, C McGuire, WC McGaghie (eds.), *Innovative Simulations for the Evaluation of Professional Competence.* Chicago: Department of Medical Education, University of Illinois Medical Center.1999.

10. Keys B, Wolfe J. The role of management games and simulations in education and research. *J Manag.*1990;16: 307-336.

11. Wachtel J. The future of nuclear power plant simulation in the United States. In: DG Walton (ed.), *Simulation for Nuclear Reactor Technology.*1985. Cambridge: Cambridge University Press.

12. Office of Naval Research. *Visual elements in flight simulation*. National Council of the National Academy of Science. Jan. 1973. Washington, D.C.

13. Society of Photo-Optical Engineers. Simulators and simulation. *Society of Photo-Optical Engineers*. 1975; 59 (Session 4): 141.

14. Collins JP, Harden RM. AMEE Medical Education Guide NO. 13: Real Patients, simulated patients and simulators in medical education. *Medical Teacher*. 1998;20:508-521.

15. Norcini J. Computer-based testing will soon be a reality. *Perspectives*. American Board of Internal Medicine Newsletter for Diplomates. Summer 1999:3.

16. Robertson LJ. Twelve tips for using a computerized interactive audience response system. *Medical Teacher*. 2000;22(3):237-239.

17. Ericsson KA. *The road to excellence: the acquisition of expert performance in the arts and sciences, sports and games*, K.A.Ericsson Ed., 1996. Lawrence Erlbaum Associates, Mahwah, NJ. 1-50.

18. Harden RM, Laidlaw JM, Hesketh EA. AMEE Medical Education Guide No 16: Study guide-their use and preparation. *Medical Teacher*. 1999;21(3):248-265.

19. McNeir G. Outcome-based education, tool for restructuring. *Oregon School Study Council Bulletin, Eugene*. 1993;36(8).

20. Cohen AM. Relating curriculum and transfer. *New direction for community colleges*. 1994.No 86, 22(2).

21. Fitzpatrick KA. Restructuring to achieve outcomes of significance for all students. *Educational Leadership*. 1991; 48(8):18-22.

22. Terry PM. Outcome-based education: is it mastery learning all over again, or is it revolution to the reform movement? Paper presented at 7th Annual Midwest Education Society (CIES) Conference, Indiana.1996.

23. Harden RM, Crosby JR, David, MH. An introduction to outcome-based education. Part 1, AMEE No. 14: outcome-based education. *Medical Teacher*. 1999;21(1):7-14.

24. Ewy GA, Felner JM, Juul D, Mayer JW, Sajid A, Waugh RA. Test of a cardiology patient simulator with students in fourth-year electives. *Journal of Medical Education.*1987; 62:738-43.

25. Issenberg SB, McGaghie WC, Brown DD, et al, Development of multimedia computer-based measures of clinical skills in bedside cardiology. *Proceedings of the 8th International Ottawa Conference on Medical Education and Assessment*, 12-15 July 1998. Philadelphia, Pennsylvania.

26. Hart I. The objective structured clinical examination. In: Lloyd JS, Lansley DG (eds). *How to evaluate residents.* 1986; American Board of Medical Specialties, Chicago, Il:13-146.

27. Davis MH, Friedman Ben-David, Harden RM, et al. Portfolio assessment in medical students' final examinations. *Medical Teacher.* 2001; 23(4):357-366.

28. Gordon MS. Cardiology Patient Simulator Development of an animated manikin to teach cardiovascular disease. *Am J Cardiol.* 1974;34:350-355.

29. Gordon MS, et al,. "Harvey," the cardiology patient simulator: pilot studies on teaching effectiveness. *Am J Cardiol.* 1980;45:791-796.

30. Gordon MS, Ewy GA, Felner JM, et al, Teaching bedside cardiologic examination skills using Harvey, the cardiology patient simulator. *Med Clin North Am.* 1980;64:305-313.

31. Ewy GA, Kettel LJ. Cardiology Patient Simulator. *Ariz Med.* 1980;37(1):42-3.

32. Gordon MS, Ewy GA, Felner JM, et al. A cardiology patient simulator for continuing education of family physicians. *Journal of Family Practice.* 1981;13:353-6.

33. Gordon MS, et al. Learning through simulation: the value of patient simulators. *J Am Coll Cardiol.* 1986;8:477-478.

34. Woolliscroft JO, Calhoun JG, Tenhaken JD, Judge RD. Harvey: the impact of a cardiovascular teaching simulator on student skill acquisition. *Med Teach.* 1987;9:53-57.

35. Felner JM, Gordon MS. Newer techniques in teaching cardiology. *Emory University J of Med.* 1988;2(3);151-157.

36. Sajid AW, Ewy GA, Felner, et al. Cardiology patient simulator and computer-assisted instruction technologies in bedside teaching. *Medical Education.* 1990;24:512-517.

37. Nammack GSS. Teaching auscultation with high-tech adjuncts. *Cardiovascular Review & Reports.* 1991;12(8):46, 49-51,68.

38. St Clair EW, Oddone EZ, Waugh RA, Corey GR, Feussner JR. Assessing housestaff diagnostic skills using a cardiology patient simulator. *Annals of Internal Medicine.* 1992;117:751-6.

39. Oddone EZ, Waugh RA, Samsa G, Corey R, Feussner JR. Teaching cardiovascular examination skills: results from a randomized controlled trial. *Am J Med.* 1993;95:389-396.

40. Gordon MS, Mayer JW, Issenberg B: Simulation Technology in Medical Education. *Miami Medicine.* 1995;66:33-35.

41. Westman EC, Matchar DB, Samsa GP, et al. Accuracy and Reliability of Apical S3 Gallop Detection. *Journal of General Internal Medicine.* 1995;10(8):455-7.

42. Issenberg SB, Browne SM, Gordon MS. Medical education in the 21st century: simulation technology and multimedia computer instruction. *Arquivos Científicos.* 1997;36-38.

43. Jones JS, Hunt SJ, Carlson SA, Seamon JP. Assessing bedside cardiologic examination skills using "Harvey," a cardiology patient simulator. *Acad Emerg Med.* 1997;4:980-985.

44. Issenberg SB, McGaghie WC: Assessing knowledge and skills in the health professions: a continuum of simulator fidelity: In: *Innovative simulations for Assessing Professional Competence.* Chicago, IL: Dept. of Medical Education, University of Illinois Medical Center; 1999:157-174.

45. Gordon MS, Issenberg SB, Mayer JW, Felner JM. Developments in the use of simulators and multimedia computer systems in medical education. *Med Teacher.* 1999;21:32-6.

46. Issenberg SB, McGaghie WC, Hart IR, Mayer JW, et al, Simulation Technology for Health Professional Skills Training and Assessment. *JAMA.* 1999;282:861-866.

47. Gaskin PRA, Owens SE, Talner NS, et al. Clinical Auscultation Skills in Pediatric Residents. *Pediatrics.* 2000;105(6):1184-7.

48. Nurko J, Unzek S, Gitler R, Magana F, Hurtado D, Padilla L, Di Silvio M. El simulador Harvey de paciente cardiológico. La utilización de simulaladores, computadors y equipo multimedia en el aprendizaje de la cardiología. *An Med Asoc Med Hosp ABC (Anales Medicos).* 2000;45(3):134-139.

49. Issenberg SB, Gordon MS, Stewart GM, Felner JM. Bedside Cardiology Skills Training for the Physician Assistant Using Simulation Technology. *Perspective on Physician Assistant Education.* 2000;11(2):99-103.

50. Issenberg SB, Gordon MS, Gordon DL, et al. Simulation and New Learning Technologies. *Medical Teacher.* 2001;23(1):16-23.

51. Schwindt MG, Jones JJ and Bush CM. Accuracy and Interobserver Agreement in Detecting "Gallop Sounds" Using a Cardiology Patient Simulator. *Academic Emergency Medicine.* 2001;8(5):558.

52. McGaghie WC, Issenberg SB. Acquisition and maintenance of medical expertise from deliberate practice using simulation technology. *Interface.* 2000. 12(1) accessed: http://gasnet.org/interface/12.1.3mcgaghie.html July 17, 2001.

53. Issenberg SB, Pringle S, Harden RM, Khogali S, Gordon MS. Adoption and integration of simulation-based learning technologies into the curriculum of a UK Undergraduate Education Programme. Med Educ. 2003 Nov;37 Suppl 1:42-9.

54. Issenberg SB, Gordon MS, Greber AA. Bedside cardiology skills training for the osteopathic internist using simulation technology. J AM Osteopath Assoc. 2003 Dec;103(12):603-7.

55. The Medical School Objectives Writing Group. Learning Objectives for medical student education - Guidelines for medical schools: Report I of the Medical School objectives project. *Acad Med.* 1999;74:13-18.

56. Ziv A, Small SD, Wolpe PR. Patient safety and simulation-based medical education. *Medical Teacher*. 2000;22(5):489-495.

Appendix A - Examination Categories and Findings

Jugular Venous Pulse	Disease #
Normal "a" wave larger than "v" wave	46
Giant "a" wave	20
Systolic "cv" wave	4
Equal "a" and "v" waves	23
Prominent "x" descent	30
Carotid Arterial Pulse	
Normal	46
Hypokinetic	13
Hyperkinetic	28
Bifid	1
Precordial Impulse (location / size)	
Normal location & size	46
Normal location & enlarged	33
Inferolaterally displaced & enlarged	17
Left parasternal & enlarged	3
Pulmonary location & enlarged	11
Absent apical impulse	4
Precordial Impulse (contour)	
Early systolic	46
Early brisk systolic	17
Sustained systolic	3
Presystolic + early systolic	39
Presystolic + sustained systolic (ss)	36
Sustained systolic + early diastolic	7
Presystolic + ss + early diastolic	6

First Heart Sound	Disease #/Location
Normal Single	36 (LLSE)
Normal Split	46 (LLSE)
Soft	40 (Apex)
Loud	3 (LLSE)
Second Heart Sound	
Normal Physiologic Splitting (NPS)	46 (ULSE)
NPS & loud P_2	6 (ULSE)
Paradoxic splitting	48 (ULSE)
Persistent expiratory splitting	40 (ULSE)
Fixed splitting	23 (ULSE)
Single loud A_2	36 (URSE)
Single loud P_2	11 (ULSE)
Systolic Sounds	
Ejection sound	4 (ULSE)
Systolic click	9 (LLSE)
Diastolic Sounds	
Third heart sound	46 (Apex)
Fourth heart sound	36 (Apex)
Opening snap	3 (LLSE)
Systolic Murmurs	
Early peaking & short	22 (ULSE)
Late peaking & long	13 (URSE)
Holosystolic	25 (Apex)
Late systolic	9 (Apex)
Diastolic Murmurs	
Early decrescendo & long	17 (LLSE)
Early decrescendo & short	37 (LLSE)
Long diastolic	4 (Apex)
Mid diastolic	17 (Apex)
Breath Sounds	
Normal vesicular	46 (All lung fields)
Inspiratory crackles	40 (Bilateral LPLF)
Inspiratory & expiratory crackles	48 (Bilateral U&LLF)
Inspiratory crackles & expiratory wheezes	4 (Bilateral U&LLF)
Pleural rub	30 (Lower Left A&PLF)
Absent	42 (Lower Right PLF)
Carotid sounds	
Aortic Stenosis radiation	13 (R>L Carotid Vessel)
Bruit	39 (UL Carotid Vessel)

Heart Sounds and Murmurs

URSE - Upper Right Sternal Edge
ULSE - Upper Left Sternal Edge
LLSE - Lower Left Sternal Edge

Breath Sounds

LPLF - Lower Posterior Lung Fields
U&LLF - Upper & Lower Lung Fields
A&PLF - Anterior & Posterior Lung Fields
PLF - Posterior Lung Fields

Carotid Sounds

R>L - Right greater than Left
UL - Upper Left

Appendix B

Notes for clinical facilitator in a sample basic core integrated cardiology course.

WEEK 1: Arterial Pulses, JVP, Precordial Impulses and Heart Sounds	
Arterial pulses	
1	Introduce students to examination of arterial pulse (rate, rhythm and volume)
2	Normal pulse: Harvey #46
3	Hyperkinetic pulse: Harvey #28
4	Hypokinetic pulse: Harvey #13
5	Bifid pulse: Harvey #1
Jugular Venous Pulses	
1	Introduce students to JVP examination
2	Normal JVP: Harvey #46
3	Giant "a" wave: Harvey #20
4	Pathologic "CV" wave: Harvey #4
Precordial Impulses	
1	Introduce students to precordial impulses
2	Normal apical impulse: location and contour: Harvey #46
3	Enlarged and sustained apical impulse (LVH): Harvey #33
4	Displaced apical impulse (LVD): Harvey #17
5	Left parasternal heave (RVH): Harvey #3
Heart Sounds	
1	Introduce students to heart sounds
2	Listen to first and 2nd heart sound: Harvey #46 (upper right sternal border)
3	Listen to physiological splitting of 2nd sound: Harvey #46 (upper left sternal border)
4	Listen to 3rd heart sound #46 (Apex)
5	Listen to 4th heart sound #36 (Apex)
WEEK 2: Introduction to Murmurs	
Murmurs - Systolic and Diastolic	
1	Introduce students to murmurs
2	How to time a murmur
3	Systolic murmur: Harvey #13 (upper right sternal border): aortic stenosis
4	Diastolic murmur: Harvey #17 (lower left sternal border): aortic regurgitation
5	Description of murmur: location, timing, duration, character (pitch), intensity (grading) and radiation
6	Listen to mitral murmurs
WEEK 3: Review and More Murmurs	
Common Murmurs	
1	Give students opportunity to ask questions and consolidate previous teaching
2	Listen to innocent murmur: Harvey #22
3	Aortic stenosis: Harvey #13
4	Aortic regurgitation: Harvey #17
5	Mitral stenosis: Harvey #4
6	Mitral regurgitation, chronic: Harvey #7

Appendix C

Sample Checklist for Student Cardiac Physical Examination

#	THE STUDENT APPROPRIATELY EVALUATED THE FOLLOWING:	✔
1	Heart rate and respiratory rate	
2	Blood pressure	
3	Carotid pulse - including contour and timing with other pulses or sounds	
4	Peripheral pulses - including brachials, radials and femorals	
5	Jugular venous pulse - including central venous pressure, contour and timing with arterial pulse or heart sounds	
6	Precordial inspection - including visible impulses	
7	Precordial palpation, apex - including location, size and contour	
8	Precordial palpation, parasternal - including location, size and contour	
9	Auscultation at aortic area (upper right sternal edge)	
10	Auscultation at pulmonary area (upper left sternal edge)	
11	Auscultation at tricuspid area (lower left sternal edge)	
12	Auscultation at apex	
13	Auscultation - use of bell vs. diaphragm	
14	Auscultation - timing with arterial impulse or other heart sounds	

Center for Research in Medical Education
Medical Training and Simulation Laboratory
University of Miami School of Medicine
P.O. Box 016960 (D-41)
Miami, Florida 33101

Tel: (305) 243-6491
Fax: (305) 243-6136
www.crme.med.miami.edu