Evaluation of the use of Laerdal MicroSim as an adjunct to traditional learning methods for teaching Advanced Cardiovascular Life Support

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university.

Signed:_____

Neil Reddy

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List of figures used in this document (with page numbers)

Summary

This dissertation describes the current state-of-the-art in simulation technology used in healthcare education. A research study is also presented, describing the Evaluation of Laerdal MicroSim as an adjunct to traditional learning methods for teaching Advanced Cardiovascular Life Support. The objectives of the research were to elucidate any difference in objective outcomes (multiple choice examination score and skills assessment score) or subjective outcomes (candidate satisfaction with the course and program) between a test and control group. The test group used the MicroSim program for an amount of time of their own choice in the week before an ACLS course in addition to the normal textbook study, pre-course MCQ and rhythm evaluations. Both groups were chosen at random from the list of candidates for 5 ACLS Provider courses in Ireland, between June and August 2005. In total, 78 candidates took part in the study (39 test, 39 control). No statistically significant difference was found between the MCQ result (93.49 and 92.72, p=0.24) and the skills assessments (98.36 and 97.13, p=0.11) for the test and control groups, respectively. Subjective outcomes tended to be better in the test group but were not statistically significant. Overall, the use of the program was well received in terms of enjoyment, ease of installation and relevance to the ACLS course. Those with better perceived computer literacy found the program easier to use and got more enjoyment out of it. 84% of the test candidates enjoyed the program and 74% would recommend the program to a friend. 61% expressed an interest in receiving ACLS Certification by using a self-directed curriculum of which the MicroSim program would form the biggest part. This study, although of small sample size, does show that screen-based simulators are generally well-received by ACLS candidates of varying computer-literacy.

Abstract

OBJECTIVES: to evaluate the difference made to students' outcomes by using Laerdal MicroSim ACLS simulator in addition to traditional learning methods prior to an ACLS course. METHODS: 78 candidates (39 test, 39 control) were chosen randomly from the candidate list of 5 ACLS courses. Test candidates received the MicroSim program for one week prior to taking the ACLS Provider course. Both groups completed the normal textbook study and pre-course MCQ and Rhythm recognition tests. Objective outcomes were Post-Course MCQ result and Megacode Skills evaluation score. Subjective outcome was candidate satisfaction assessed by post-course questionnaire. The ACLS course was conducted as normal and the instructors were blinded as to the test status of the candidates. OUTCOMES: There was no significant difference between the test and control groups in terms of MCQ result (93.49 and 92.72, p=0.24) or skills assessments (98.36 and 97.13, p=0.11). Although the subjective outcomes tended to be better in the test group, the results were also not statistically significant. Overall satisfaction with the ACLS course was very good. Overall satisfaction with the MicroSim program was also good, but was influenced by the perceived computer-literacy of the test participants. CONCLUSIONS: screen-based simulators such as Laerdal MicroSim are well received by ACLS candidates and do not seem to have any negative impact on the skills or knowledge of the candidates when used as an adjunct to the textbook for traditional ACLS courses.

Chapter 1 - Introduction

1.1 Background

This dissertation describes an evaluation of a commercially-available computer program (Laerdal MicroSim), designed to simulate the management of critically-ill patients in a hospital environment as part of the ACLS (Advanced Cardiovascular Life Support) educational program for healthcare professionals. The preparation work was carried out between October 2004 and June 2005, while the actual evaluation took place between June 2005 and August 2005.

The ACLS course was introduced in 1974 by the American Heart Association (AHA) as a way to disseminate the latest evidence-based guidelines and to standardise the care of critically ill patients **(1).** It has since been adopted in over 30 countries. The first courses were taught in Ireland in 1999 by the Irish Heart Foundation (IHF) under official license from the AHA.

The course is an intensive, 2-day, instructor-led course, taught by a combination of lectures, small-group discussions and hands-on practical training. The official AHA textbook is a comprehensive guide to the theory of managing a cardiac arrest using evidence-based guidelines and is provided to each candidate and few weeks before the course. Although, anecdotally, the candidates are generally happy with the way the course is taught, the large amount of information presented in a short time allows inadequate time for practice of scenario-management and skills.

The solution offered by Laerdal MicroSim is a multimedia, screen-based computer simulator. This program presents the candidates with a cardiac emergency scenario, allowing them to choose interventions with realistic results, giving the candidate feedback at the end of the scenario. The program can be used as an adjunct to the textbook prior and after to the course or may form part of a self-directed ACLS certification curriculum, which is in the implementation process in the United States.

1.2 Objectives

The objectives of the research part of this dissertation are

- To evaluate the difference made by using the program prior to an ACLS course in terms of the objective course outcomes of a multiple choice question exam (MCQ) result and Skills assessments.

- To evaluate candidate satisfaction and enthusiasm for this method of learning in terms of their subjective opinions regarding the program and the course itself.

1.3 Dissertation Structure

Chapter 2 describes the State-of-the-art of both ACLS and of computer simulation technologies as applied to healthcare.

Chapter 3 describes the design of the study and the methods used for recruiting, informing and evaluating the participants.

Chapter 4 details the implementation of the study. It also describes the difficulties encountered with logistics and course heterogeneity.

Chapter 5 presents the results of the study under the headings of objective outcome (MCQ and Skills Assessments) and subjective outcome (participant satisfaction and opinion). The methods used for data analysis are presented in this chapter.

Chapter 6 contains the author's conclusions drawn from the information gathered in this study. It also presents a discussion of the importance of this data for future ACLS Simulation.

Appendices – this section contains the original Questionnaires used in the study, a glossary of terms and abbreviations, sample MCQ and Skills Assessments and the official AHA ACLS Algorithms.

CD-ROM – the CD provided in the inside cover of the dissertation is a demonstration copy of Laerdal MicroSim, which will give the user 2 hours use of the program and one cardiac emergency scenario.

Chapter 2 - State-of-the-art

2.1 Advanced Cardiovascular Life Support (ACLS)

2.1.1 History

The American Heart Association guidelines for Advanced Cardiovascular Life Support were developed during the 1970s and have been revised on a number of occasions since then, as new evidence-based recommendations emerge, with a major revision in 2000. **(2)** The guidelines are updated every couple of years after a major AHA conference at which the latest research trials are presented and debated by panels of experts, following rigorous evidenced-based guidelines. The next conference takes place in Houston, Texas in November 2005.

There are International Training Centres in over 33 countries, including Ireland – The Irish Heart Foundation. The International Training Centres teach the ACLS guidelines as issued by the AHA but are allowed some flexibility in terms of local practices e.g. availability of different drugs or procedures. Certification in ACLS is issued by the local training site under licence from the AHA. The ACLS certification is recognised in all countries that follow the AHA guidelines.

Some European countries (including UK) have adopted the guidelines issued by the European Resuscitation Council (ERC) – developed separately to the AHA guidelines. Although the actual guidelines differ in only minor ways, certification by one organisation is not recognised by the other. The International Liaison Committee

on Resuscitation (ILCOR) was formed in 1992 to provide a forum for liaison between principal resuscitation organisations worldwide.

Last year 1900 healthcare professionals received ACLS certification in Ireland. There are over 18 licensed training sites in Ireland, mostly based in hospitals. The course may be taken by any healthcare professional but the majority of candidates come from critical care areas – doctors, nurses, emergency medical technicians (EMTs) and cardiac technicians. Certification is a requirement of some postgraduate training programmes, including intensive care (ICU/CCU) nursing diploma, specialist registrar training (SPR) and general professional training for doctors (GPT). Candidates must retake the course every 2 years to maintain certification.

Trainee doctors receive full funding for the cost of the course (350-500 Euro), nurses and cardiac technicians receive partial or full funding depending on their employer, while EMTs usually have to pay the full cost.

2.1.2 General principles

Resuscitation guidelines – including AHA and other models – are based around the evidence that more people can survive sudden cardiac arrest when a particular sequence of actions are performed as rapidly as possible – The Chain of Survival.

The Chain of Survival **(3)** is

1. Early access to the Emergency Medical System (EMS)
2. Early Cardiopulmonary Resuscitation (CPR)
3. Early defibrillation
4. Early ACLS

1. Early Access to EMS. Persons discovering a critically-ill or dead victim should assess the seriousness of the situation and call for help – an ambulance and a defibrillator – straight away. Trained responders should be available 24 hours to the community and have a sufficiently rapid response time.

2. Early CPR. Non-medical persons may be trained in basic life-support techniques to be used until professional help arrives.

3. Early Defibrillation. The most effective treatment (defibrillation) for the most common reason for cardiac arrest (ventricular tachycardia/fibrillation) is now available to non-medical responders in almost any situation. The machine used to deliver the defibrillation shock is an Automated External Defibrillator and requires

only basic training in its use – usually taught with CPR on a basic life-support (BLS) course.

4. Early ACLS. Advanced interventions to treat the cause of cardiac arrest and prevention of further injury are provided by professional responders and by prompt transfer to a properly equipped hospital.

Steps 1 to 3 may be performed by anyone, whether a healthcare professional or a trained bystander and in any location, in or out of hospital. This forms the basis for Basic Life Support (BLS), a course also licensed by the American Heart Association and taught in most hospitals and many communities in Ireland.

While the ACLS course concentrates on the advanced interventions of step 4, the other links in the chain are also assessed – candidates are required to have attended the basic life support (BLS) course prior to the ACLS.

The ABCD Approach

In-hospital treatment of cardiac arrest is managed by a team of healthcare professionals – generally 2-3 doctors and 2-3 nurses. The ACLS course teaches candidates how to manage such a team while following the AHA Algorithms to choose the appropriate intervention at the appropriate time. The ACLS interventions are prioritised by the primary and secondary "ABCD" surveys, as shown below.

Primary ABCD survey

- **A**irway: assess for patency. If it is closed, open it with a head-tilt and chin-lift manoeuvre. Maintain with a non-invasive device e.g. oropharyngeal airway.

- **B**reathing: assess for breathing. If the victim is not breathing, give rescue breaths with 100% oxygen, if available.

- **C**irculation: assess for a pulse. If there is no pulse, start chest compressions to generate a pulse. Co-ordinate the chest compressions with the rescue breaths at a ratio of 15 compressions: 2 rescue breaths.

- **D**efibrillation: assess the victim's cardiac rhythm. If the rhythm is ventricular tachycardia or ventricular fibrillation, deliver defibrillation shocks.

Secondary ABCD survey

- **A**irway: secure the airway against vomiting by inserting an invasive airway device e.g. endotracheal tube.

- **B**reathing: give rescue breaths using 100% oxygen and assess for proper circulation of that oxygen.

- **C**irculation: continue chest compressions to generate a pulse. Insert an intravenous cannula to give drugs and fluids.

- **D**efibrillation: continue to give defibrillation shocks if the cardiac rhythm remains ventricular tachycardia or ventricular fibrillation.

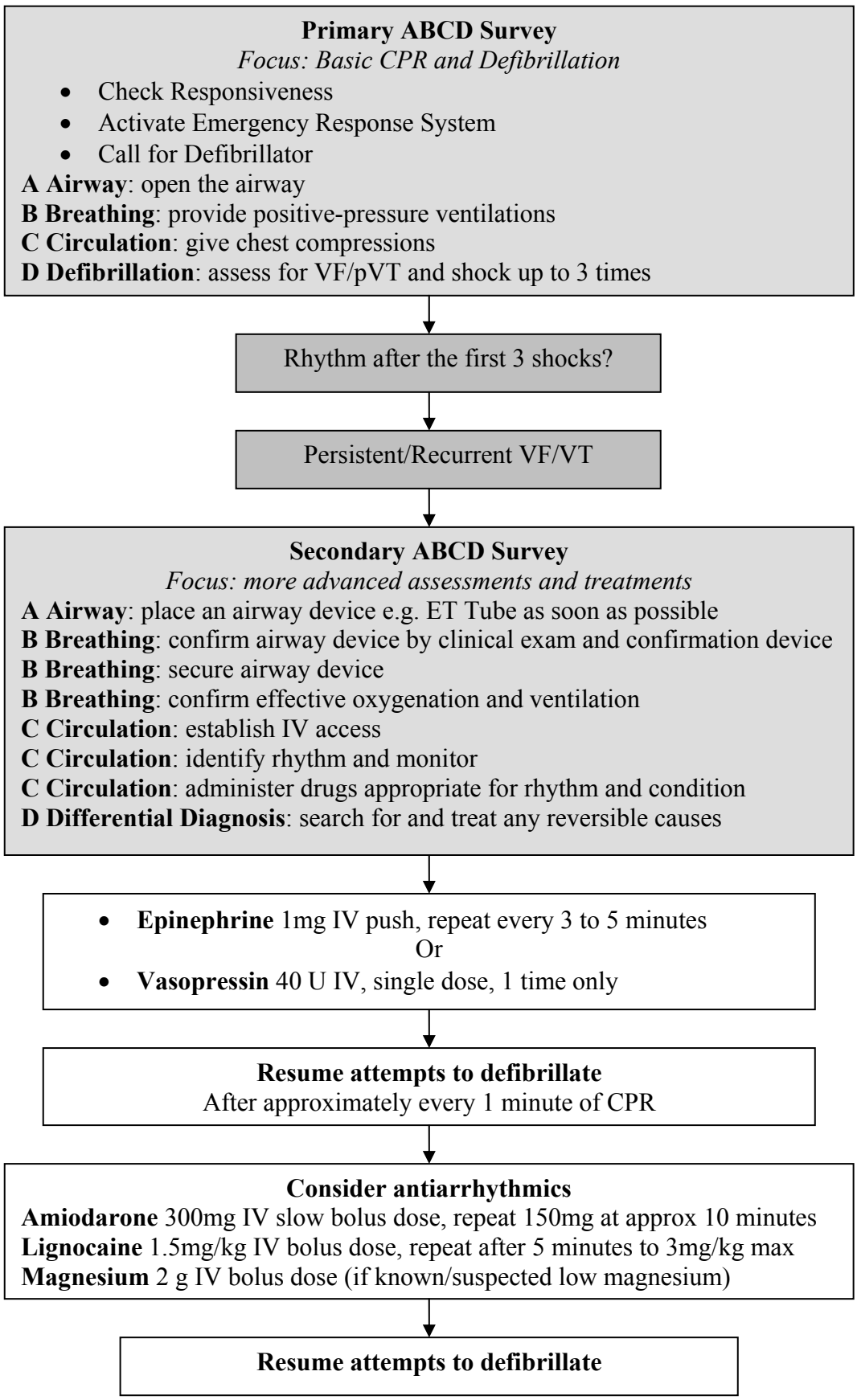
- **D**iagnosis: attempt to find and reverse the cause of the cardiac arrest by examination or taking blood samples.

Adapted from AHA and ILCOR Guidelines 2000 for cardiopulmonary and emergency cardiovascular care: an international consensus on science**. (4)**

The ABCD surveys provide the team leader with a framework for making decisions during the cardiac arrest, prioritising interventions when resources are limited. When full resources are available to the team, the A, B, C and D steps of the surveys may be carried out simultaneously.

Management of specific cases (the 10 core cases of ACLS) is simplified by an algorithmic approach, based on the patient's ECG rhythm. An example of the algorithm for management of Ventricular Fibrillation/Pulseless Ventricular Tachycardia is shown below.

VF/pVT Algorithm (See Appendix 7 for the other ACLS Algorhithms)



Training hospital staff in the application of ACLS techniques has been shown to directly improve patient survival. Dane et al, analysed the outcome of cardiac arrest in the Medical Centre of Central Georgia from 1996-1997. The initial cardiac arrest rhythm was found to be the single strongest predictor of survival outcome (57% of the variability, Ventricular Tachycardia and Ventricular Fibrillation having the highest survivability). Of the 120 cardiac arrests recorded, those that were discovered by an ACLS-trained nurse had a survival rate of 38% while those discovered by a non-ACLS-trained nurse had a survival rate of 10%. The study allowed for other nurse and patient factors which may have influenced the outcome but none had any significant effect. Why ACLS training had such an effect on survival was not studied. **(5)**

2.1.3 The ACLS Course

The ACLS course in Ireland is taught over 2 days, with a minimum ratio of 1 instructor per 3 candidates – this differs from the AHA recommendation of 1:8. More instructors per candidate place a logistic and financial burden on the organisers of the course to find and fund the extra instructors. Typical numbers would be 24 candidates and 8 instructors but there is no limit to how big or small the course may be. The usual venue is the education department of a general hospital but any venue, e.g. a hotel conference room, would suffice. The course runs from 8am to 6pm on both days, with a 45-minute break for lunch. Prior to the ACLS course, the candidates complete a Pre-Course MCQ and ECG Rhythm interpretation exam which are handed in to the RTO and corrected before the course starts.

The candidates learn by

- Lectures involving all the candidates at once (for management of Acute Coronary Syndromes and Stroke). The lectures are usually delivered by a specialist in Cardiology or Neurology but may be also be given by the course director or other suitably qualified instructor.
- Small-group practical sessions (for management of cardiac arrest, tachycardias and bradycardias). The groups of 6-8 candidates at the practical sessions are generally of mixed speciality and experience.

(Figure 1. A typical ACLS Skills Training Station. Courtesy of ACLS Training Services, Dublin, Ireland)

Candidates are required to demonstrate their knowledge, practical skills and team-leading skills in front of the instructors and the rest of the group. Practical skills are

taught using real life equipment on advanced simulation manikins which may be ventilated, intubated, defibrillated and cannulated, depending on the model. Although the manikins are quite hi-fidelity (most manikins give realistic feedback for breathing, pulse and cardiac rhythms), they require candidates to use some degree of imagination when running the cardiac arrest scenarios.

A typical scenario might start by the instructor providing the candidate with some information: "You are passing through the medical ward late at night when a student nurse runs up to you and tells you that a patient has collapsed in one of the private rooms. You enter the room to find the patient lying on a bed. Take it from here…" The candidate then assesses the patient, asks for help from the rest of the team and begins the ABCD surveys, using the ACLS algorithms.

Assessment of the candidates is continuous. The instructors at each teaching station tick a checklist of required actions (for an example, see appendix 4) while a candidate is managing a scenario. At the end of each day the checklists are gathered together and an overall impression of the candidate's knowledge and skills is established. The MCQ is sat on the afternoon of the second day, usually at the end of the course.

(Figure 2.Running a typical cardiac arrest scenario. Courtesy of ACLS Training Services, Dublin, Ireland)

Despite the emphasis on continuous assessment, the candidate is still required to run a complete cardiac arrest on the afternoon of the second day – "The Megacode". This allows the candidate to demonstrate his/her skills and knowledge of the algorithms and ABCD surveys all at once in a real-time scenario with no prompting by the instructors.

Some candidates find the experience of being assessed in a group in front of their peers a very stressful experience. While those who are totally unable to learn because of the stress are in a very small minority, most candidates experience some degree of stress. A Brazilian study found that those candidates with a 10% or greater variation in heart rate and blood pressure (both are indicators of stress) while managing scenarios achieved worse results than those who had a variation from base heart rate and blood pressure of less than 10%. The reason for this was not elucidated**. (6)**

The criteria for completing an ACLS course are

- Achieve 84% or higher on the post-course MCQ
- Pass an assessment of Basic Life Support
- Be able to manage the first 10 minutes of a cardiac arrest
- Demonstrate ability to perform the following skills

    Airway management

    Effective CPR

    ECG Rhythm interpretation

    Defibrillation

    Use of drugs to treat cardiac arrest

The ACLS course is not supposed to be a statutory requirement, according to the AHA and the IHF. It has, however, become a statutory requirement for some specialities because of the protocols of the governing bodies of those specialities. The Royal College of Physicians in Ireland (RCPI), for example, insist that ACLS certification be acquired in order to complete General Professional Training (GPT). For those candidates, not passing the ACLS course will have serious consequences for their employment status.

The results of each ACLS course are sent to the Irish Heart Foundation, which issues the certificates approximately 3-4 weeks later.

2.1.4 Challenges

There are a number of challenges facing ACLS candidates.

Finding funding and study leave for the 2-day course can be a problem for some specialities. Even when study leave is available, it may be difficult for some candidates to co-ordinate with their work colleagues to cover their workload while they are away on the course. A 1-day course is being introduced this year in Ireland for those who have taken the 2-day course within the past 2 years and just want to re-certify. This 1-day course is not available to first-time ACLS candidates.

The AHA textbook explains the guidelines in a very comprehensive way, giving detailed instructions, levels of evidence and research references for each intervention. While this dedication to evidence-based medicine is necessary for the success and spread of the guidelines, some candidates find the book hard to read. It does give them a good idea of what they will be expected to do on the 2-day course, but when it comes to leading a team of professionals at a cardiac arrest, no book can realistically describe the real-time flow of assessments and interventions required. Some candidates do not see cardiac arrests on a regular basis and some are even from non-critical areas where cardiac arrests are very infrequent occurrences. For these candidates, the organisation of a cardiac arrest team and the application of the ABCD surveys is a novel concept.

Candidates also complain of a lack of opportunity to practice skills and cardiac arrest management on the 2-day course. This may be due to the intensive nature of the

course – many new skills learned over a short period of time – and due to the small-group method of learning, where only one candidate may be taught at a time. The practical sessions last approximately 45 minutes each, so when an instructor spends time with one candidate, the others in the group can only watch. Facilities available one the course, typically one advanced manikin per teaching station also limit the number of opportunities each candidate gets to practice skills or run a scenario.

Computer-based simulators offer candidates the opportunity for real-time practice of the ABCD surveys and cardiac arrest management. They can provide feedback to the candidate on their performance prior to the ACLS course, thus directing them to study their areas of poor performance.

The simulator can also be used as an assessment tool itself and thus form part of the certification process, as used in the US as part of the ACLS Anywhere Self-Directed Certification Process. See chapter 2.2.3 for a full description of this programme.

2.2 Simulation Technology in healthcare

2.2.1 History

Simulation in medicine is not new – techniques such as practising suturing on pig's feet or using an orange to learn injection techniques have been commonplace for decades, even centuries. All that is needed for simulation is an organised interaction with one or more of the trainee's senses – visual, auditory, tactile, gustatory or olfactory. The closer the experience is to the trainee's expectations of real-life, the more immersive the experience becomes.

Modern technology has made possible hi-fidelity, immersive simulators which have become vital to some professions e.g. aviation, military. Simulator training for airline pilots is known to be a major factor in the reduction of accidents since its introduction in the 1970's **(7).** The totally believable "holodeck" experience, as seen on Star Trek, remains the Holy Grail of simulation technology.

2.2.2 Benefits

- **Safety.** Simulators provide safety, for both the patient and the trainee, while practising high-risk procedures. The Institute of Medicine Reports on preventing medical errors recommended the evaluation and use of simulators as tools to raise standards among medical professionals. The undergraduate emphasis on theoretical knowledge leaves graduates under-prepared in terms of practical skills, which must then be learned "on the job" and sometimes at

the patient's expense **(8).** By training or educating the healthcare professionals in a simulated environment of the educator's choice, a culture of safety or teamwork may be fostered, away from the pre-existing difficulties such as peer influence and fear of litigation hampering such a transition in the real world.

- **Ethical and logistical considerations.** There are major ethical and logistical difficulties with practicing on real patients especially during cardiac arrest. Informed consent is often lacking when invasive or innovative procedures are performed or practised. While practices such as post-mortem intubation may benefit the trainee, the ethical dilemma of performing an unnecessary procedure on a deceased person is of some concern. **(9) (10) (11)**

- **Feedback.** Simulators give the trainer and the trainee immediate feedback. The effects of a procedure or intervention on a real-life patient may not be evident for hours or days, depending on the intervention. This does, of course, rely on accurate modelling of the real-world in the design of the simulator. Apart from education and training, simulation tools may be used for performance assessment on an ongoing basis. An example of this type of simulation includes trained actors playing "patients" in a clinical exam setting **(12) (13).** This has the advantage of being infinitely reproducible for all trainees, thus maintaining a specific desired standard for the examination.

- **The opportunity to simulate uncommon but important scenarios.** Some healthcare professionals are exposed to emergency situations on a regular basis. Others, however, work in non-critical areas where emergencies are uncommon. These professionals are still required to have a certain competency in the management of these emergencies. Simulators offer educators the ability to provide training at a convenient time and location, in controlled circumstances. Trainees may then run the same scenario multiple times.

2.2.3 Current techniques

Table 1 provides a summary of the types of simulators available today, grouped in terms of the technology employed and the fidelity of the simulation. Almost all of these categories have been utilised in the field of ACLS.

Simulation Tool	Description
Low-tech simulators	Anatomical models e.g. manikins
Simulated Patients	Real actors trained to play the role of patients
Screen-based computer simulators	Computer programs presenting problem-solving scenarios and assessing user inputs
Complex task trainers	High-fidelity feedback devices that simulate a particular task e.g. surgery
Realistic Patient Simulators	Full-size manikins with realistic anatomy and physiology used to present realistic scenarios to one or more trainees.

Low-tech simulators.

ACLS skills may be practiced anatomical models of varying functionality. Real-life equipment may be used to practice intubation, for example, on a life-sized, functional model of a patient's head, trachea and lungs.

(Figure 4. Intubation Trainers – Adult and Neonatal – from Laerdal. Used with permission. Http://www.laerdal.com)

Similarly, a plastic model of a patient's arm, filled with a red dye, may be used to practice intravenous cannulation. These models are robust and relatively inexpensive.

(Figure 5. Multi-Venous Task Trainer Kits from Laerdal. Used with permission. Http://www.laerdal.com)

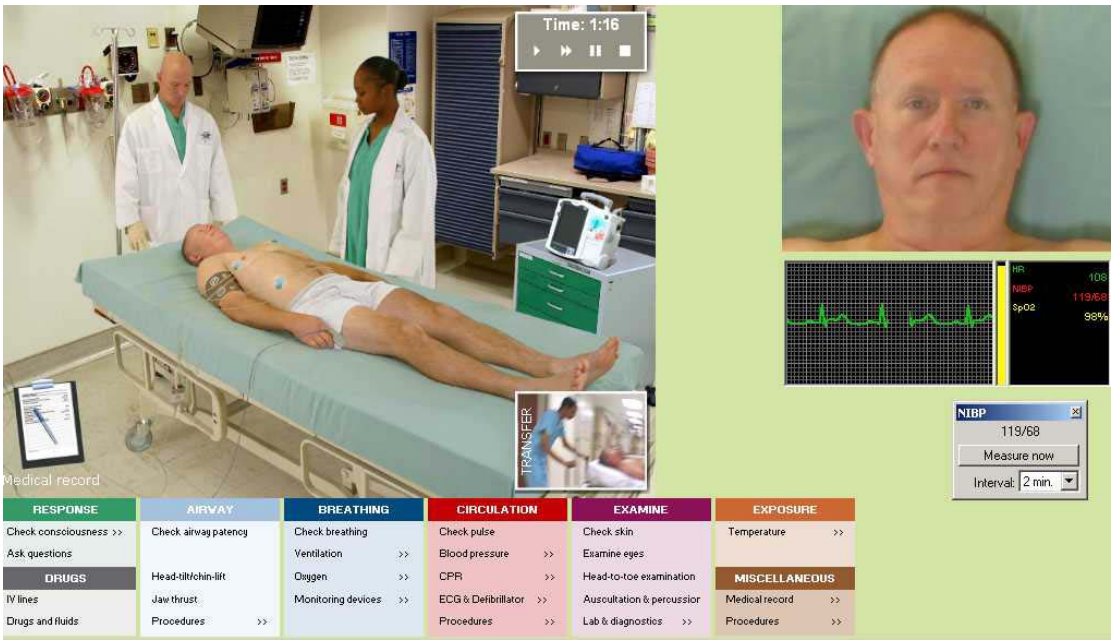
Standardised/simulated patients.

While not used frequently in the field of ACLS, these become standard practice for examinations in other fields, particularly in undergraduate and postgraduate clinical exams (OSCE – Objective Structured Clinical Examination) where actors play the part of patients and allow the examiners test the candidate's history-taking and examination technique.

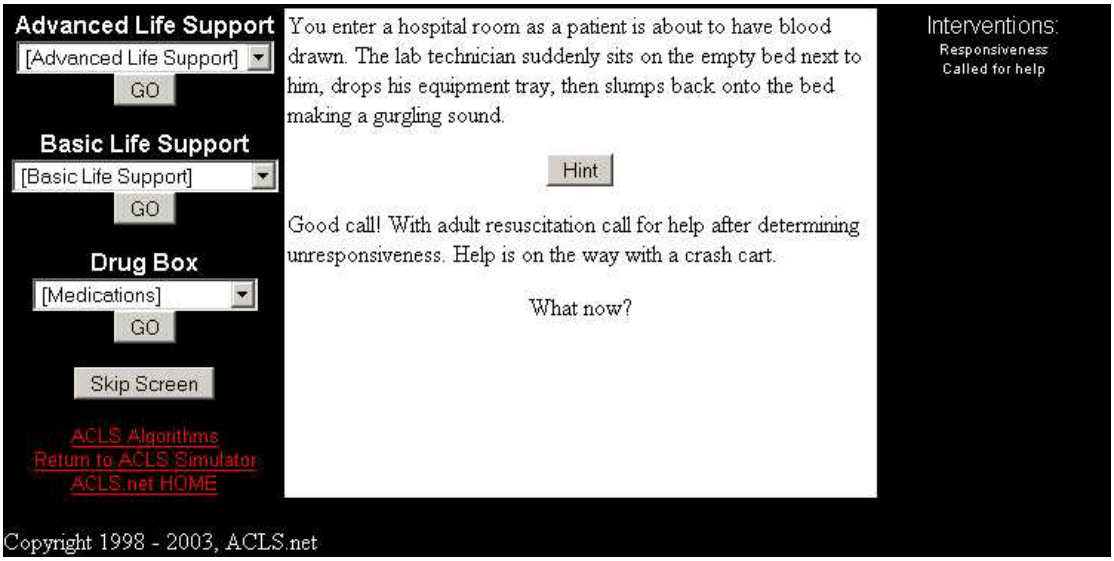
Figure 6. Simulated patient encounter using actors. Courtesy of Connolly Hospital, Ireland.

Screen-based computer simulators.

Web-based simulators, such as that found on www.acls.net, are generally text-based, with some photos or diagrams to illustrate cardiac rhythms or interventions. Advanced multimedia such as video clips tends not to be useful because of bandwidth limitations for many users. Simulators based on CD-Rom offer the opportunity for more graphic-heavy, multimedia applications such as Laerdal's MicroSim and Mad Scientist's CodeTeam. Animations, audio and video create a more immersive, real-life experience.



(Figure 7. MicroSim Advanced Life Support Simulator from Laerdal. Used with permission. Http://www.laerdal.com)



(Figure 8. ACLS Web Simulator from ACLS.net. Used with permission.)

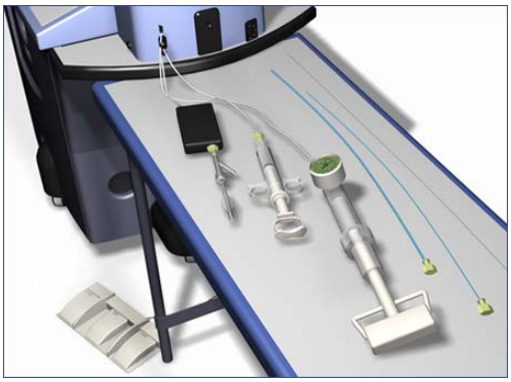
Research involving screen-based simulators is slow but recent trials have shown at least equivalent, if not favourable, results when compared to traditional learning methods along**. (14)**

Complex task trainers.

These simulators provide hi-fidelity feedback to the trainee via one or more senses e.g. haptic (touch) feedback in laparoscopic (keyhole) surgery simulators.

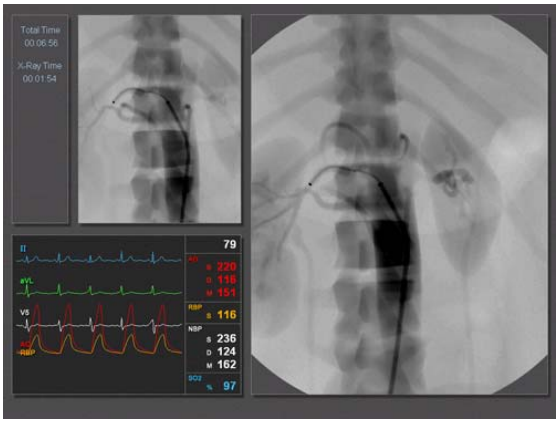
Virtual reality trainers have been proven to improve standards in operative procedures such as endoscopy and laparoscopic surgery. Seymour et al (2002) found that residents trained on a virtual reality haptic simulator completed their surgeries more quickly and with less errors than those trained by traditional methods – i.e. observation and practice in operating theatre. **(15) (16)** Current applications of such trainers include laparoscopic surgery, endoscopy and angiography.

These complex task trainers provide the trainee with the opportunity for repetitive skills training for tasks which would be quite challenging and/or high-risk in real-life e.g. angiographic carotid artery stenting, laparoscopic coronary artery bypass surgery. More importantly, the simulators track the trainee's progress in acquiring the skills in question. The standard to be achieved by the trainee may be set by having the expert (or a number of experts) use the simulator first.

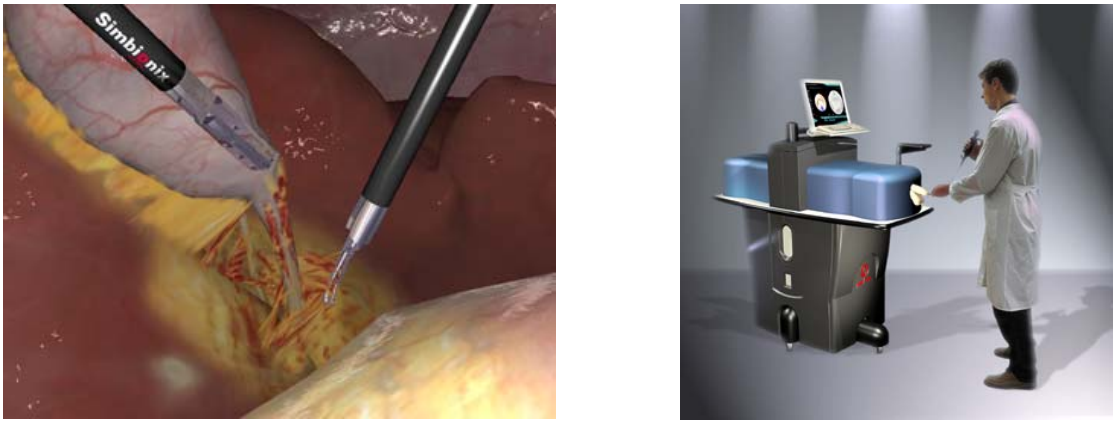


(figure 9. Simbionix AngioMentor Angiography Simulator. Used with permission. http://www.simbionix.com)

The simulator itself need not even look like the patient (or part of the patient) in question. As long as the feedback from the machine (visual or haptic) is accurate enough, the experience will be immersive and valuable to the trainee.



This is a picture of the feedback given to a trainee using the Simbionix AngioMentor Simulator. The X-Ray picture and ECG readouts are exactly the same as would be seen by a clinician carrying out the procedure in real-life.



(Figure 10. LapMentor Laparoscopic Simulator from Simbionix. Used with permission. http://www.simbionix.com)

A trainee using the LapMentor Laparoscopic Simulator receives both visual feedback in the form of anatomically accurate representations of the surgical field (in this case, it is the gall bladder) and haptic feedback from the instruments (in this case, a curved dissector and a straight scissors).

An extension of the complex task-trainer in recent years had led to the development of robotic surgery systems such as Da Vinci. Using the Da Vinci system, the surgeon sits at a console next to the operating table and views the operative field via endoscopic cameras. Two fibre optic cameras positioned side-by-side in the endoscopes provide the surgeon with a 3-dimensional view of the operative field through binoculars. The surgeon manipulates mock endoscopic tools in the same way as in the laparoscopy simulator and his/her inputs are digitally captured and transferred to the actual endoscopic tools inside the patient. The tools used have the same degrees of freedom as the surgeon's wrist and fingers. In contrast to non-robotic endoscopic tools, the robotic instruments do not pivot at the patient's body wall, so the movements of the surgeon's instruments are not inverted i.e. moving the hand up moves the tool up and vice versa. The advantages of this kind of surgery are its minimal invasiveness (the instruments are introduced through 1cm ports in the patient's body wall compared to a full chest or abdominal incision in traditional surgery) and the stability of the robotic instruments compared to human surgeons. The disadvantages are obviously the high cost of setting up such a system (this may be offset by shorter procedures and fewer complications but this is as yet unproven) and the necessity of conversion which may be up to 35% of cases (see below).

Research has shown that the system is clinically effective for complex procedures such as Totally Endoscopic Coronary Artery Bypass-Grafting. As the surgical team

perfected the interaction with the robotic system, operative times were significantly reduced. The rate of conversion i.e. encountering a problem which causes the surgeons to abandon the robot for traditional methods, also reduced to a moderate rate, in comparison to non-robotic Totally Endoscopic Coronary Artery Bypass-Grafting. **(17)**

Realistic Patient Simulators.

ACLS manikins provide the trainee with the opportunity to practice skills such as airway management and intubation, defibrillation (using real defibrillators), IV cannulation and, depending on the model, some invasive procedures such as cricothyrotomy and needle thoracostomy. These manikins start at approx 4000 Euro and may cost as much as 20,000 Euro.

(Figure 11. Laerdal Megacode Kelly and Control Unit. Used with Permission. Http://www.laerdal.com)

The manikins are linked to computer software which the instructor uses to manipulate the response of the manikin to interventions by the trainee. These manipulations may be done in advance, thus allowing the instructor to create standard scenarios which

may be saved and reproduced for multiple candidates. The manikin can be set up to provide feedback through many modalities e.g. touch (pulse), auditory (breathing sounds, electronic (a stimulus to monitoring devices such as an ECG monitor).

Most ACLS manikins are portable, so they may be used in the trainee's work setting e.g. in the resuscitation room in an emergency department, using the trainee's usual equipment and monitors.

Research has shown that the use of medium and high-fidelity manikin simulations for training purposes is acceptable to trainees and provides at least as good a level of competency as traditional learning methods. The simulators were used to train both undergraduate and post-graduates medical staff in emergency procedures such as airway management and cardiac arrest management. The improvement in skills attained was transferable to the bedside clinical practice of the trainees. The trainees also got the opportunity to practice their theoretical knowledge in a safe and realistic setting, reflected in the positive feedback for this type of learning. **(18)**

2.2.4 Laerdal MicroSim

Development

The program was developed by a multidisciplinary team in Copenhagen, Denmark. The development company was originally called Sophus, but was bought out by Laerdal prior to the MicroSim project.

Laerdal Inc. started in Stavanger, Norway and has become one of the major suppliers of medical equipment worldwide, specialising in emergency medical devices. It has international sites in 16 countries.

MicroSim was released in the USA in 2002 and has since been accredited by the American Heart Association for self-directed ACLS certification. The product name for this use is HeartCode and contains the assessment modules, the AHA guidelines and teaching modules such as ECG rhythm recognition.

MicroSim has been slower to take off in the UK, because it has only achieved UK Resus Council accreditation in September 2005. There are no plans as yet to launch a self-directed certification program in the UK similar to that used in the USA.

The program is available from Laerdal UK on a single-user license. This version contains 5 scenario modules with 5 scenarios each and also contains the ERC guideline. The cost of £105 + VAT includes updates of the ERC guidelines when they are revised, downloadable from the Laerdal Support site.

System Requirements

Windows 95, 98, ME, 2000, XP, NT (No Mac/Linux version as yet)

Pentium II 233MHz (450MHz recommended)

32MB RAM (128MB recommended)

300MB Hard Disk space

256 Color (16 bit recommended)

Display adapter, sound adapter

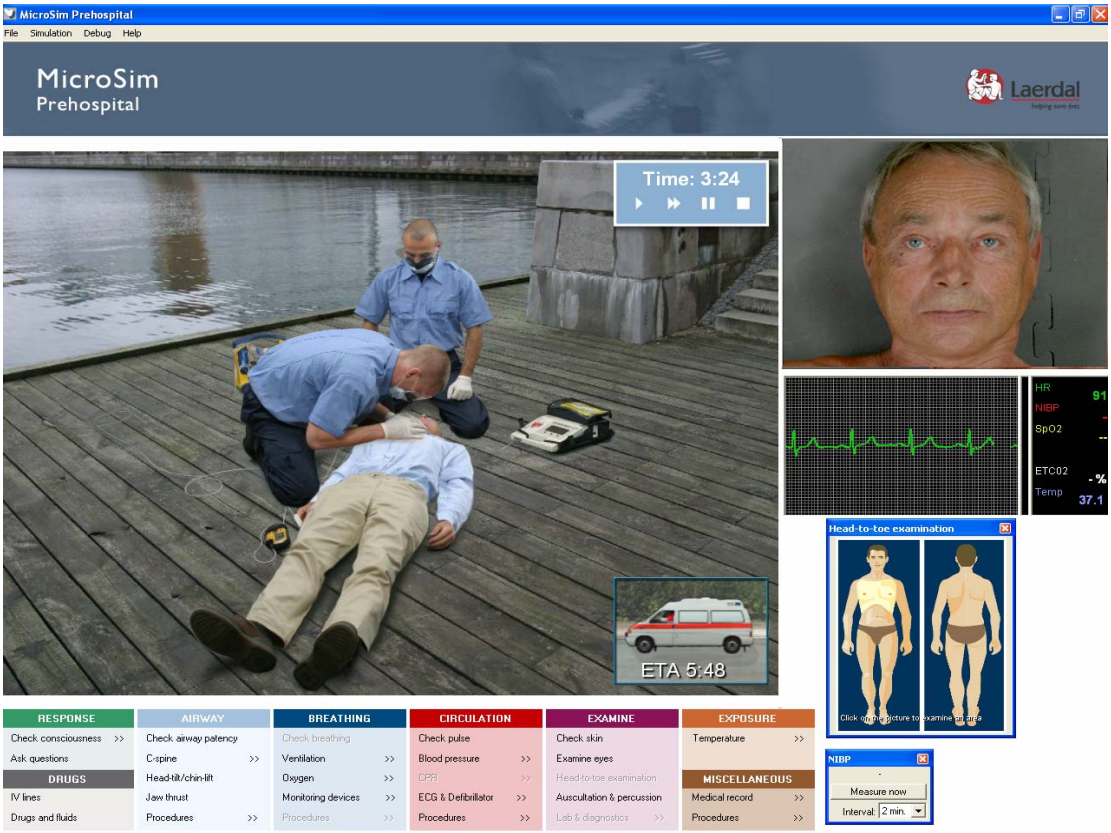
Mouse or other pointer

The CD-Rom is presented in a cardboard sleeve, without any instruction manual. Brief installation instructions and the minimum requirements are printed on the back of the sleeve.

Content

Laerdal MicroSim is available for 3 classes of user

- In-hospital (Doctors, nurses, respiratory therapists, cardiac technicians)
- Pre-hospital (paramedics, EMTs)
- Military (Armed forces doctors, nurses and paramedics)



(Figure 12. MicroSim Pre-hospital. Courtesy of Laerdal. Used with Permission)

This study used the in-hospital version of MicroSim, so the following discussion will focus only on that version.

The program has two modes.

- Demo: allows the user free access to one full chest pain scenario with full functionality of the program. The demo lasts 2 hours.
- Licensed: the full program may be activated by entering a licence key. This may be obtained by purchasing online from Laerdal or may be provided by the users institution.

The rest of this description will focus on the full version.

The opening screen contains links to and brief descriptions of the tutorial and test scenarios, licence entry, help files and program development credits. It also contains a

list of all of the test scenarios – 40 in total. The scenarios are divided into categories similar to how the scenarios are taught on the 2-day ACLS course:

Airway and Breathing 1

Cardiac Arrest 1

Cardiac Arrest 2

Cardiac Arrhythmia 1

Cardiac Arrhythmia 2

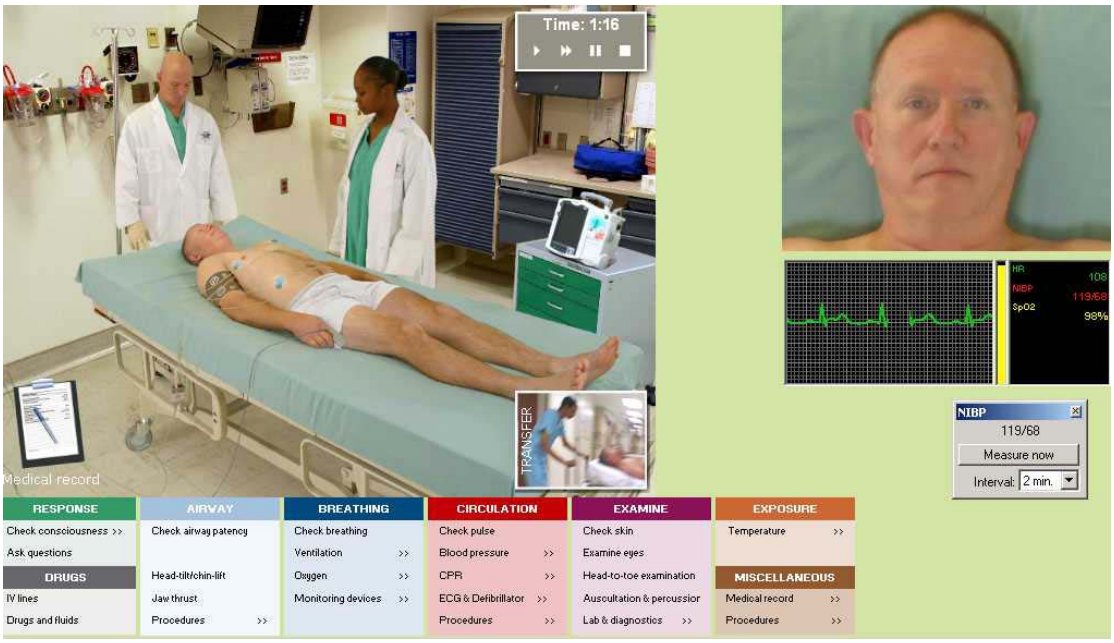
Chest Pain 1

Metabolic and Environmental 1

Poisoning and Overdose 1

The scenarios descriptions give a brief patient history and the level of difficulty of the case (beginner, medium, advanced). The cases may be attempted in any order.

Interface



(Figure 13. The user interface for the cardiac arrest scenarios in Laerdal MicroSim. Courtesy of Laerdal. Used with permission.)

The MicroSim interface is similar to those used by other screen-based simulators.

The large picture on the left shows the patient lying on a trolley in a typical hospital emergency room, with two medics in attendance. The equipment surrounding the scene is broadly familiar – this is certainly helped by the fact that Laerdal is itself one of the biggest suppliers of emergency room equipment worldwide so many emergency room personnel will be using exactly the equipment shown.

The smaller pictures focus on particular areas of interest. Following the ABCD protocol taught by ACLS course, the pictures show the patients head (Airway and Breathing), vital signs (Circulation) and cardiac rhythm (Defibrillation).

The lower part of the screen is occupied by the text-based menus for assessments and interventions, again divided up into ABCD areas, plus specific areas of drugs and clinical examination.

New windows pop up for assessments and interventions e.g. Intravenous fluid infusions.

The interface provides the user with numerous ways to interact with the scene

- **Text-based menus:** clicking on a menu option opens a pop-up window with some options related to the menu item. When the user clicks on the required option, the pop-up window closes automatically. This tends to save screen space and make the screen less cluttered with specific options.

- **Medics:** clicking on a medic opens a pop-up window with the assessments or interventions available to that person. The initial pop-up window contains only the most common interventions. Less common interventions can be accessed by going through submenus from that pop-up window.

- **Patient:** clicking on an area of the patient's body (highlighted by a colour-change when the mouse moves over it) brings up a pop-up window of interventions and assessments which may be performed on that specific area.

- **Equipment:** clicking on a piece of equipment in the emergency room (highlighted by a colour-change when the mouse moves over it) brings up a pop-up window of uses for that equipment e.g. drugs trolley, suction machine and defibrillator.

The range of pathways to access the desired action tends to reduce the number of dead-ends encountered when navigating text menus which may be organised in a manner different to the user's expectations.

Scenarios

The scenarios presented by Laerdal MicroSim correspond reasonably well with the 10 Core Cases of ACLS.

Laerdal MicroSim Scenario	ACLS Core Case
Airway and Breathing 1	Respiratory Compromise
Cardiac Arrest 1	VF treated with CPR and AED
	VF/Pulseless VT – Persistent/Refractory
Cardiac Arrest 2	Pulseless Electrical Activity
	Asystole
Cardiac Arrhythmia 1	Tachycardias
Cardiac Arrhythmia 2	Bradycardias
Chest Pain 1	Acute Coronary Syndromes
Metabolic and Environmental 1	
Poisoning and Overdose 1	
	Acute Ischaemic Stroke

Table 2. MicroSim Scenarios and ACLS Core Cases

The "Metabolic and Environmental" and "Poisoning and Overdose" scenarios do not correspond directly to an ACLS Core case but do correspond to the "Advanced Challenges in Resuscitation" teaching station. This station is not an assessment station but has many applications in real-life, especially for senior Accident and Emergency staff.

The most notable absence from the scenario list is an "Acute Ischaemic Stroke" scenario. The management of acute stroke has become a requirement on ACLS courses and, although not fully implemented in Ireland due to poor resource availability, still forms a significant part of the ACLS MCQ exam.

Feedback

The scenario is ended by the user clicking on the transfer button in the lower right. This gives the user a number of options

- Stop further treatment
- Discharge the patient home
- Transfer to another ward e.g. ICU

The program asks the user "Was this the best way to treat this patient?" This gives the user a chance to think about their management of the case. If the user is unhappy about the way the case went, he/she can restart the case and try again.

If the user is happy with the way the case went, the program offers detailed feedback on each intervention/assessment carried out during the scenario.

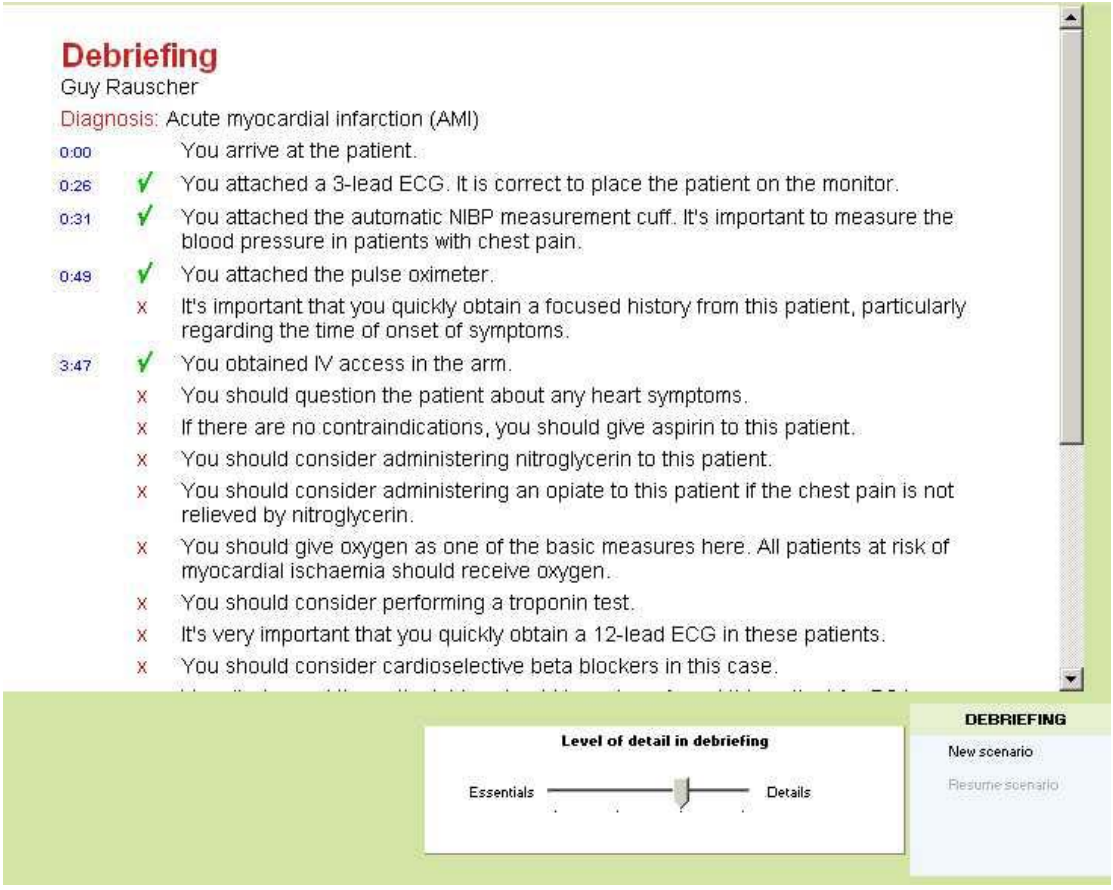


Figure 14. MicroSim feedback screen.

The level of detail can be increased, providing the patient's vital signs at the time of the intervention for reference. Higher levels of detail also provide links to the page of the Official AHA ACLS Textbook which deals with the intervention in question.

This link between the program and the Official AHA ACLS Textbook is, in my opinion, one of its most useful features. By using the simulator, candidates can identify their own areas of weakness and focus their bookwork in those areas.

Self-directed Learning Curriculum

Laerdal MicroSim forms part of a self-directed certification process for ACLS Certification in the US, called Heartcode ACLS Anywhere. The certification process has 2 steps: completion of the CD-based assessment and completion of the skills check.

The CD costs approximately 100 Dollars on its own, or 175 with the skills check included in the price. Users complete the 10 core case scenarios on their own time. The program also includes an Airway and ECG Rhythm Interpretation module which guides the user in recognition of the ECG rhythms encountered in the case. When the modules are completed, the user must complete the MCQ examination. On completion of these steps the user may print out a completion certificate.

The next step is to take that certificate to an approved ACLS Training Site for a 20 minute skills check (within 120 days) which includes

- Basic Life Support (can be waived if the user has an up-to-date BLS certificate)
- Successful management of a simulated VF/VT arrest and 2 other simulated scenarios
- Ability to manage a simulated patient's airway competently
- Demonstration of intubation (if within the user's scope of practice in real-life)

The Training Site then issues the ACLS Certificate.

Because of the brevity of the period of skills training, the ACLS Anywhere Certification process is suitable only for those who have already completed the full 2-day ACLS course and are wishing to maintain their certification within the 2 years.

To date, no research has been published as to whether the users of the ACLS Anywhere re-certification process have equivalent, or better, knowledge and skills to the ACLS providers who re-certify by the usual process.

Chapter 3 – Study Design

The main focus of this thesis is a prospective, randomised, controlled evaluation of the benefits of Laerdal's MicroSim as an adjunct to traditional learning methods for Irish ACLS candidates.

Objectives

- To evaluate the difference made by using the program prior to an ACLS course in terms of the objective course outcomes of MCQ result and Skills assessments.

- To evaluate candidate satisfaction and enthusiasm for this method of learning in terms of their subjective opinions regarding the program and the course itself.

3.1 Objective Outcome Evaluations

The objective outcomes were taken directly from the ACLS course results.

MCQ. The MCQ exam is taken by all candidates at the end of the ACLS course. It consists of 33 questions over 45 minutes, with a pass mark of 84% i.e. 28 out of 33. The MCQ paper is standardised throughout ACLS courses, with only 2 versions in circulation.
(see Appendix 5 for a sample MCQ question)

Skills assessments. ACLS candidates are required to run a full mock cardiac arrest scenario sometime during the 2 days of the course. This is usually done on the afternoon of the second day, when the candidate has had an opportunity to learn the practical skills. Candidates will generally have already run 2-3 mock scenarios each by this time at various practical stations. The skills assessment result used in this study were measured by applying a scoring system (agreed on by a sample of ACLS instructors) to the standard skills assessment sheets. The instructors involved in marking the skills assessment sheets were blinded as to the test category of the candidates.

(see Appendix 4 for the skills assessment sheet and scoring system)

3.2 Subjective Outcome Evaluations

The subjective outcomes were evaluated by anonymous questionnaires filled by both test and control groups of candidates prior to and after the ACLS course. See Appendix 1 for the questionnaires in full.

3.2.1 Pre-course questionnaire

General Information. This section aims to document the demographic and occupational characteristics of ACLS candidates which, anecdotally, are thought to influence their experience of the ACLS course.

- Speciality
- Seniority
- Does the candidate work in a critical care area?
- Is there a language barrier to participating in the ACLS course?

Computer skills. General "computer-literacy" is assessed here to determine whether is has an influence on the candidate's experience of the simulator program. Both test and control groups are questioned to determine the penetration of computer skills in the ACLS candidates as a whole. This information will influence the possibility of implement a programme similar to ACLS Anywhere in Ireland.

- Hardware availability
- Computer experience
- Computer-based education experience

Expectations of an ACLS simulator. The section provides both sets of candidates an opportunity to express their expectations of a simulator prior to using MicroSim and also provides some "market research" to determine what the Irish ACLS candidates actually think they *need* from an ACLS simulator program.

- Important qualities e.g. easy to install, multimedia, officially endorsed

Expectations of ACLS course. Both groups are questioned on their ACLS experience and attitudes to adult learning.

- Previous experience
- Reasons for taking ACLS course
- Perceived skill level
- Attitude to group learning
- Attitude to pre-course study

3.2.2 Post-course questionnaire

Evaluation of ACLS Course. Both test and control candidates evaluate the specific ACLS course, instructor and venue. There will be some variation in response expected between candidates from different courses because the instructor quality and facilities vary somewhat between training sites. The important outcome here will be the difference in experience between the test and control groups.

- Quality of the material
- Quality of Instruction
- Relevance to work
- Experience of group learning
- Opinion of specific parts e.g. MCQ, lectures, skills stations

Evaluation of Laerdal MicroSim. Only the test group respond to this section. The questions are based on Nielsen's Heuristic evaluation of user interfaces and program design. The responses are, of course, subjective.

- Installation
- User Interface
- Real World match
- User Control and freedom
- Consistency and Standards
- Error Prevention
- Enjoyment

Attitude to Future plans. The candidate's enthusiasm for the possibility of a self-directed learning curriculum in Ireland and the cost of such a programme is evaluated in this section.

- Self-directed learning
- Cost

Chapter 4 - Implementation

4.1 Logistics

Preliminary work on the research part of this thesis began in October 2004 when all Irish ACLS training sites were asked by the author to participate in the trial. All accepted enthusiastically.

The author then sampled the state-of-the-art ACLS simulators available and chose Laerdal MicroSim because it is the program to be used by the AHA as part of the ACLS Anywhere program in the US. Contact was made with the Laerdal representative in Ireland and the process of acquiring the discs and the licences was begun. The software was released here in January 2005 but, due to logistical problems, the discs and licences were received in late May. This significantly reduced the amount of time available to the author to conduct the trial, since the thesis was due in September 2005.

There are, on average, six ACLS courses of 6-24 candidates each month in different training sites around Ireland. For each course, the sequence of events was as follows:

- At least 3 weeks prior to the course: contact the RTO and obtain the list of candidates.

- 3-2 weeks prior: randomly assign half the candidates to “test” and half to “control”. Each candidate was contacted by telephone or email and asked to

participate in the trial. The response of each was noted. If the candidate accepted, they were sent either the Pre-Course Questionnaire and the Laerdal MicroSim Disc ("test" group) or just the Pre-Course Questionnaire ("control" group).

- 1 week prior: the "test" candidates use the Laerdal MicroSim program for an amount of time chosen by them.

- At the course: both cohorts take the course as normal. Instructors carry out their usual assessments of MCQ and skills checks, blinded to the trial group of the candidates.

- At the end of the course: both cohorts of candidates complete the Post-Course Questionnaire. The Laerdal MicroSim discs are collected.

Difficulties

MicroSim discs

The major setback to the implementation of this study was the late availability of the MicroSim discs. This was due in part to the fact that Laerdal do not have a direct representative in Ireland. Their business is conducted through a company called Cardiac Services Ltd., which represents a number of international companies trading in emergency supplies. Cardiac Services are a very busy company and did not have the resources to follow up my requests for information and disc availability.

In retrospect, I should have moved to dealing directly with Laerdal UK sooner. Once I did make contact with Laerdal UK in April, it was a matter of weeks before I had the discs and licences in hand.

Candidate enrolment

Almost all candidates who take an ACLS course work in a hospital and most work in the hospital where the course will take place. RTOs, therefore, don't need any more details than hospital bleep number or ward telephone number to contact the candidates and don't ask for any more than this on the course application form. This proved to be a major headache for me. Many doctors are too busy to answer outside calls while at work. Nurses do not work 9-5 Monday to Friday (they work long shifts of 12 hours 3.5 days per week) and their wards are reluctant to give out their colleague's work schedule over the phone to a stranger.

The solution to this was to actually go into the hospital and bleep the doctors from a hospital phone so they would answer. Then I would physically go to the nurses' wards and find out when they were working. This was obviously not feasible for the courses in Tralee and Cork since I live in Dublin. For these courses, I had to ask the RTOs to try to gather this information for me. I didn't want to put too much extra work on the RTOs, who have a busy job as it is, but I had to get the candidates somehow.

In retrospect, I should have asked the RTOs to ask for a mobile phone number on the application form.

Logistics

Because the period of study was so short, the courses used were very close to each other. This made getting the discs out to candidates, back in for the course and back out for the next candidates a bit of a challenge. The x-factor of candidates losing discs, forgetting to bring them in to the course and posting them to the wrong address caused the original quota of 12 discs to drop to 10 by the last course. Only having 10 discs meant that I could enrol fewer candidates for each course.

There was nothing that could have been done about this once the trial started.

Course heterogeneity

Although the theory of ACLS is the same for each course, the practicalities of how it is run vary from hospital to hospital. The instructors are different each time, the lecturers vary in quality and clarity and even the skills assessment checklists vary. The instructors and the lecturers I could do nothing about. I had to figure a compromise between the two variations of the skills assessment checklists which included the most important parts of both. See appendix 5 for sample checklists.

Skills Assessments

When the candidates' skills are being assessed, the scenarios used by the instructors vary in the exact details and situation used. The overall scenario was always VF/VT and the skills required of the candidates were always the same.

Chapter 5 – Evaluation

In total, 78 candidates out of a possible 108 were enrolled – 39 test and 39 control. No-one refused to participate in the study when asked. The 30 candidates who did not take part were simply uncontactable before the course began, despite my best efforts.

Demographics

The major demographic difference between the test and control groups was the professional make up. There were 22 doctors in the test group compared to 12 in the control group, with 17 nurses in the test group and 26 in the control group. This reason for this bias is unknown. Other factors such as age, years of experience, sex, previous ACLS course and frequency of cardiac emergencies encountered in real-life did not differ significantly between the test and control groups.

5.1 Objective Outcomes

MCQ Stats

Does using the MicroSim program influence the MCQ test scores?

The average MCQ result for the control group was 92.72 and the average result for the test group was 93.49. The results do not show any statistically significant difference between the test and control goups (Z-test -0.69. p=0.24).

The major confounding factor in this analysis was the difference in the make up of the two groups – there were more doctors in the test group than in the control group.

Doctors achieved, on average, a higher MCQ grade than nurses (94.2 and 92.3, respectively) and this difference was significantly different (z test 1.75. p=0.04).

Skills Assessments

Does using the MicroSim program influence the Skills assessment scores?

The test group scored an average of 98.36 and the control group an average 97.13. the difference between the groups was not statistically significant (z test -1.17 p=0.11). The confounding difference caused by the larger number of doctors in the test group was not statistically significant for skills assessment scores. (average score 97.77 and 97.65, respectively. Z test -0.11, p=0.45)

5.2 Subjective Outcomes

Does using the MicroSim program enhance users' enjoyment of the ACLS course?

The candidates were given a post-course questionnaire to evaluate their attitudes to the ACLS course.

Group-learning

Overall, 10 participants found learning in a group situation difficult (3 test, 7 control). Statistically this was not a significant difference.

Too much information

Overall, 21 of the 78 participants found the course too information intensive (11 test, 10 control). Again, this did not prove to be a statistically significant difference between the groups.

Not enough time to practice

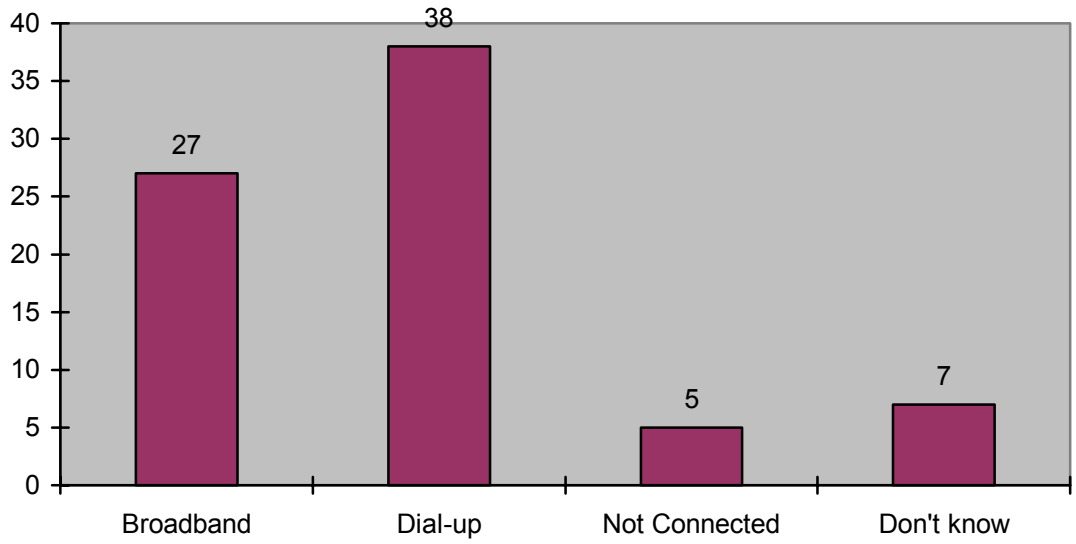
22 of the participants did not feel that they had enough time to practice the skills of ACLS and running cardiac arrests (12 test, 10 control). The result was not statistically significant.

Overall satisfaction with the ACLS course was very high. 93% of the candidates found the information presented on the course accurate. The candidates also found the quality of the instructors to be good – clarity 4.77, consistency 4.6, feedback 4.48, rapport 4.66 (results are out of a maximum of 5). The lectures were found to be good. Acute Coronary Syndromes Lecture: clarity 4.33, relevance 4.38, informative 4.33, interesting, 4.32. Stroke Lecture: clarity 4.0, relevance 3.8, informative 3.9, interesting 3.8.

Computer Access and Literacy

Of the 78 participants, 53 (69%) had access to a PC at home and 24 (31%) had access to a PC at work. One participant had access to a PC neither at home nor at work.

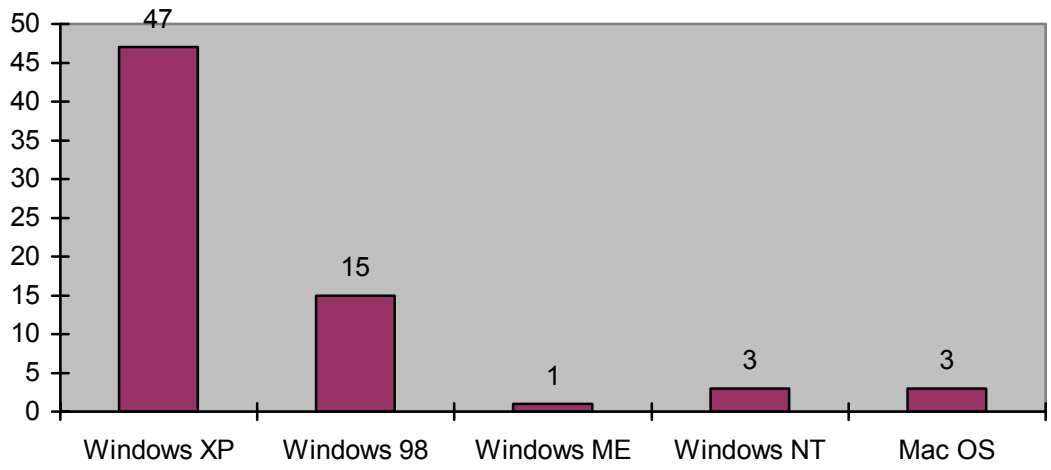
Chart 1. Internet Connection type



The internet connection type was predominantly dial-up (38 participants) and broadband (27 participants). Three of the five main hospitals from which the participants came had IT policies which blocked internet access on the ward computers. Participants could still gain access to the internet from the hospital library. This wouldn't make much of a difference to the implementation of a computer simulator program but it does have major impact on the availability of up-to-date information at point of care.

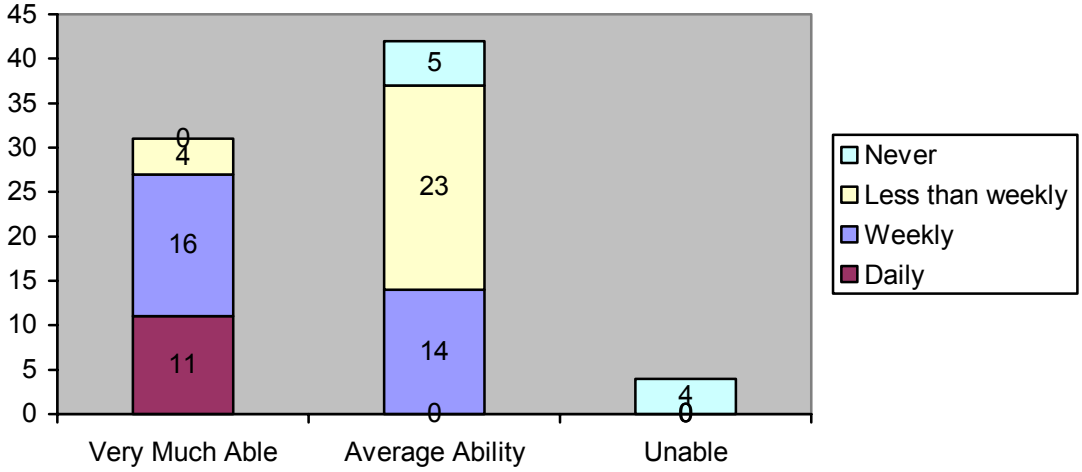
The most popular OS is Windows XP (47 participants). Three of 78 participants had an Operating System incompatible with MicroSim – Macintosh OS.

Chart 2. Operating System



The perceived computer-literacy of the participants was quite good – only 4 participants of 78 considered themselves unable to complete basic computer tasks such as word-processing, email and internet. The difference in the computer-literacy of the test and control groups was not significant. Both test participants who ranked their computer-literacy as "unable" found the program easy to install, enjoyed using it and would recommend the program to a friend.

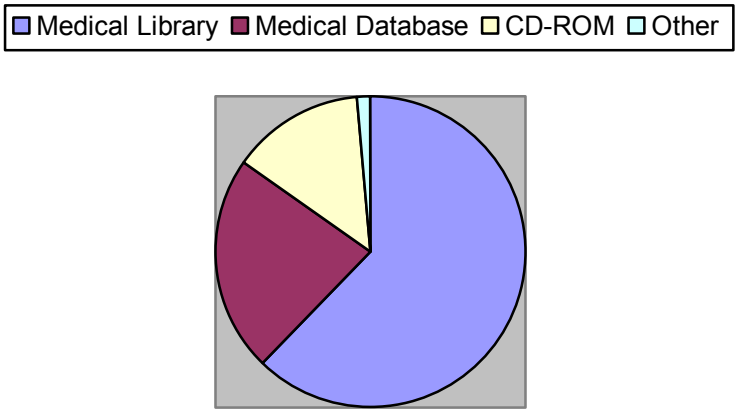
Chart 3. Computer-literacy and use of educational resources



The use of a PC for educational purposes (Medical database, Medical library, CD-ROMs) depended to a large extent on the participant's perceived computer-literacy. Those who considered themselves more computer-literate used the computer more frequently.

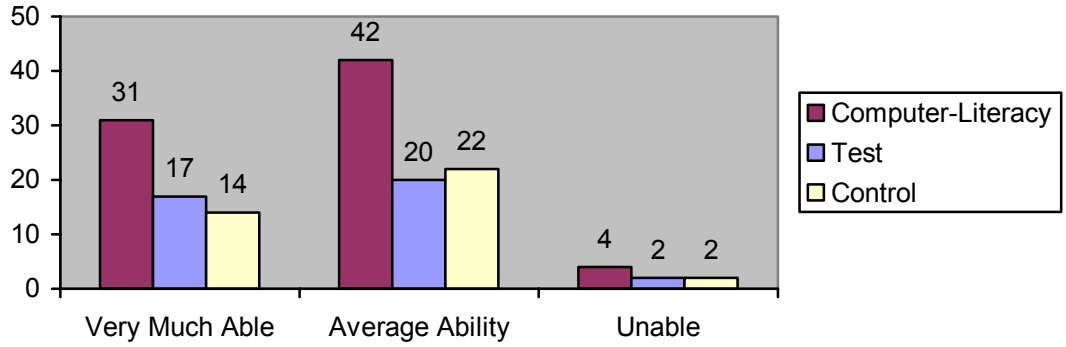
The most frequently used educational resources were medical libraries such as the Cochrane Library and on-line journals (41 participants) and Medical databases such as Medline, CINAHL (15). No participant had used a screen-based simulator like MicroSim before.

Chart 4. Educational Resources



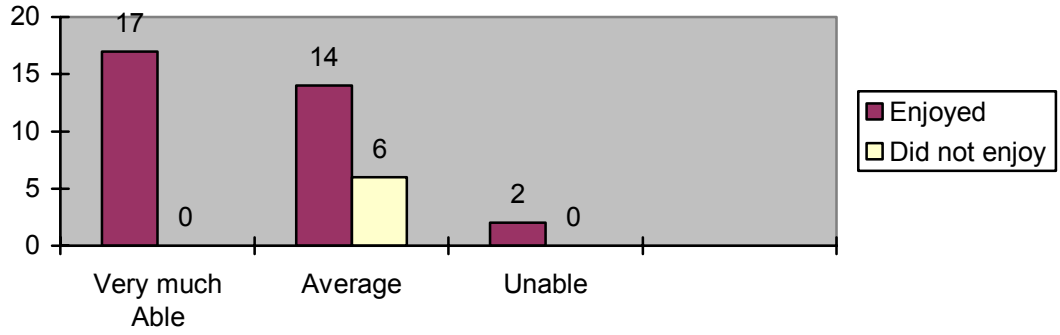
Computer literacy did have some influence over the test participant's experience of the MicroSim Program, as expected. The computer-literacy of the test and control groups did not differ significantly.

Chart 5. Computer Literacy and Test Status



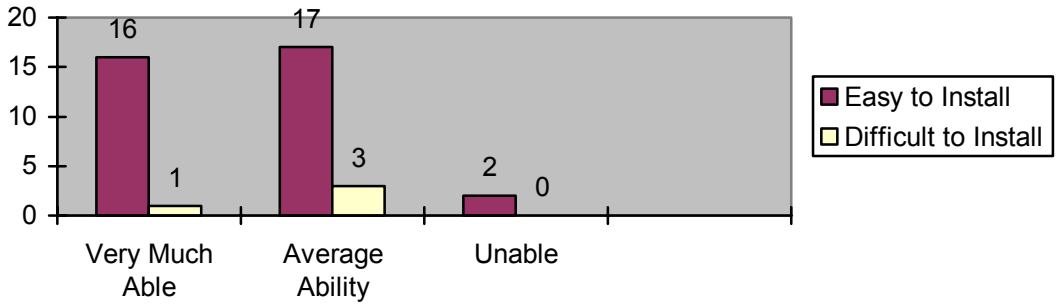
Six test participants (15%), did not enjoy using the program. Surprisingly, all six came from the average perceived computer-literacy group. Both candidates who perceived their computer-literacy to be bad enjoyed using the program.

Chart 6. MicroSim Enjoyment and Computer-Literacy



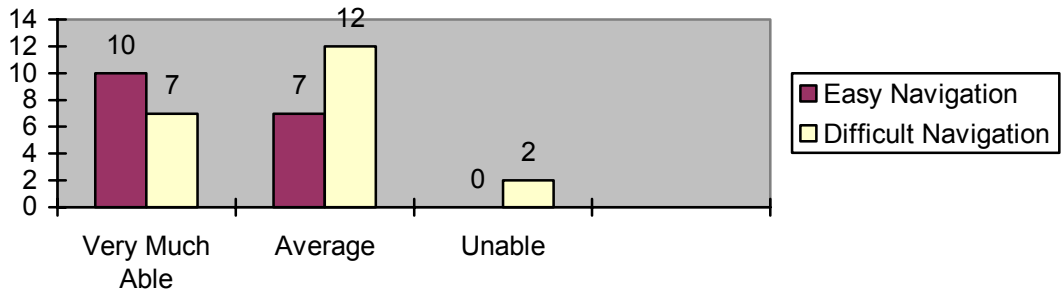
Most candidates (90%) found the program was easy to install, including the candidates with the perceived poor computer-literacy.

Chart 7. Computer-Literacy and Installation

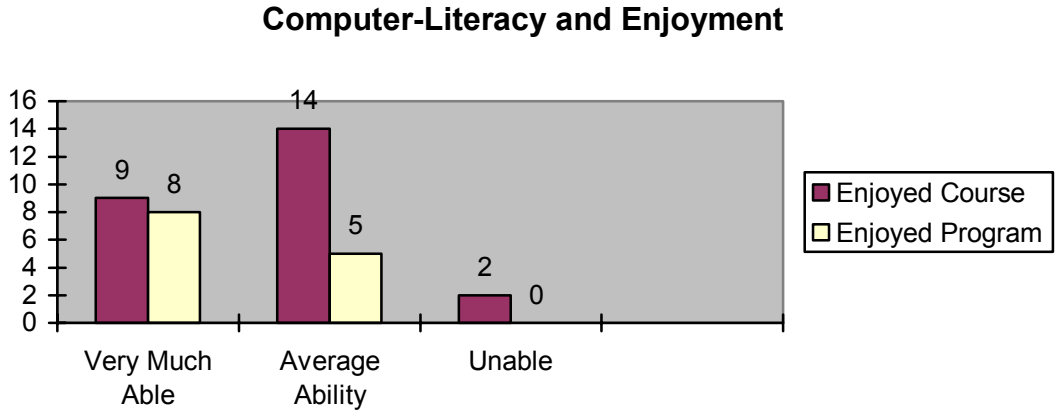


Navigation proved to be a problem for more candidates (53%), even those with perceived average or good computer-literacy. Almost all (95%) found that the scenarios became easier to navigate and control with practice.

Chart 8. Computer-Literacy and Navigation

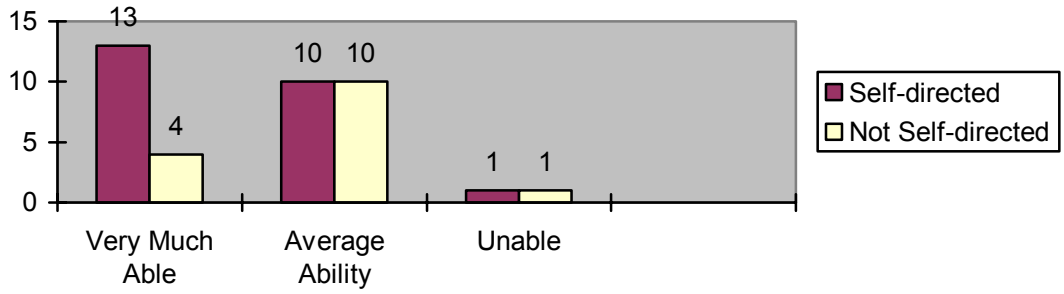


All groups tended to enjoy the 2-day course more than the program because of the hands-on instruction in ACLS skills by a skilled instructor (from the free-text box in the questionnaire). Those who enjoyed the program more tended to be from the good and average computer-literacy groups.



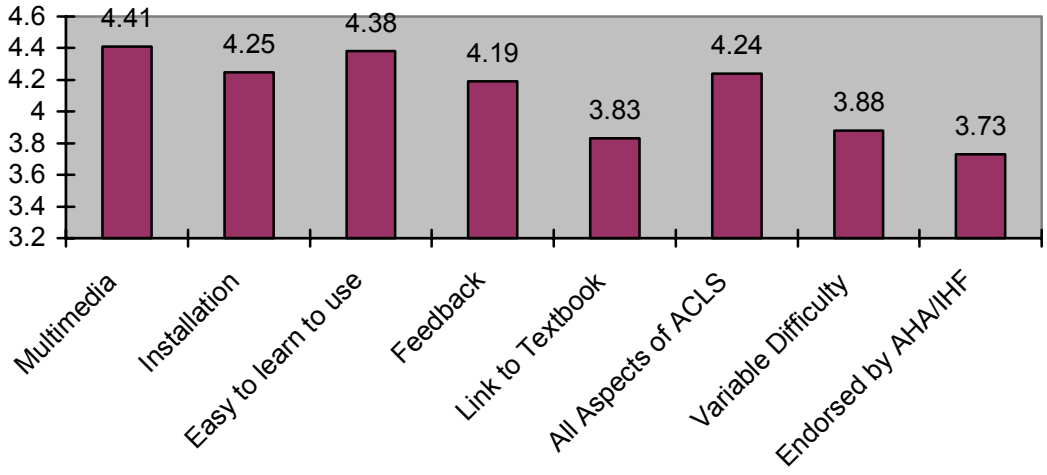
Enthusiasm for the possibility of a self-directed ACLS Certification Curriculum was highest among the groups with better computer-literacy.

Chart 9. Computer-Literacy and Self-Directed Curriculum



When both groups of participants were questioned about the features of an ACLS Simulator Program they valued the most, features like a multimedia interface and ease-of-use ranked highest. Participants were not as fussy about official endorsement or a link to the official textbook. The reason for the relatively low enthusiasm for a variable difficulty level was clear from the free text included on the questionnaire: many candidates feel that, because real-life cardiac emergencies must be treated to a certain standard no matter whom the carer is, the program should reflect that stringent standard. The MicroSim program reflects this. Even though it does separate the users in to nurse or doctor, it maintains the same standard for both.

Chart 10. Perceived important features of a screen-based simulator for ACLS



The expectations of the participants were mostly satisfied by the MicroSim program, especially ease of installation and the perceived standard of the difficulty level. Where the program did not perform as well was in the area of ease of use and the relevance to the 2-day course.

Chart 11. Satisfaction with Important Features of MicroSim Program

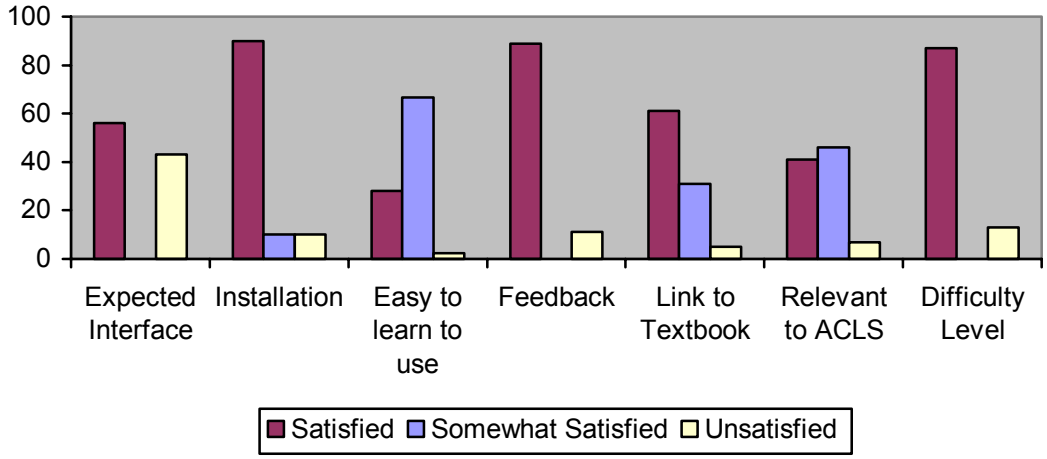
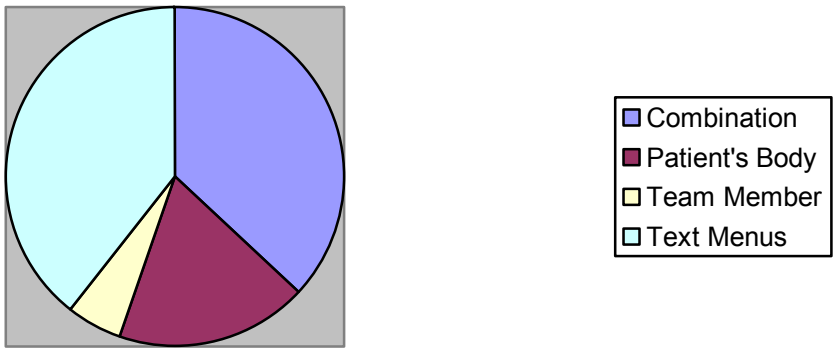


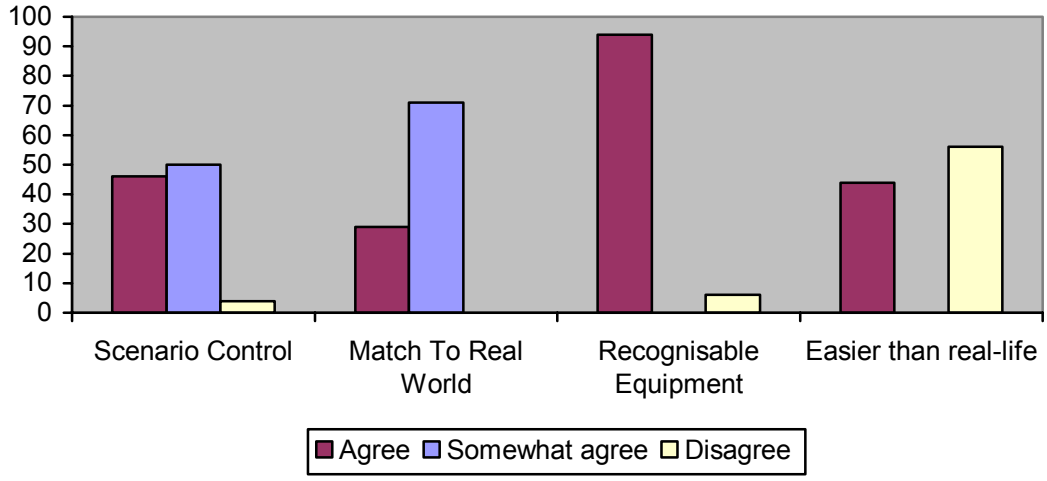
Chart 12. Action Choices in Scenario



Most test participants used either the text-based menus or a combination of methods to interact with the scenario. This may be due to the emphasis on the ABCD approach in the textbook and algorithms coupled with the way the text-menus are organised into Airway, Breathing, and Circulation.

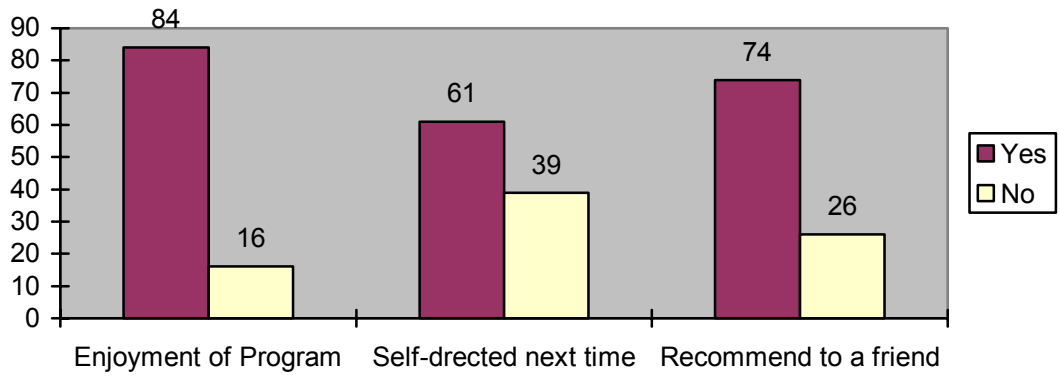
The scenarios themselves were easily recognisable to the participants and well matched to the real-world situations they encounter. What did prove a problem was control and navigation in the scenario itself.

Chart 13. MicroSim consistency with real-world



The overall impression of the program was very positive – 84% enjoyed using it and 74% said they would recommend it to a friend who was preparing for an ACLS course. I quoted a price of approximately 100 Euro in the question which is probably a little below the likely release price (£100 in the UK, $140 in the USA). Most of the people who used the program (61%) expressed an interest in the re-certifying by a self-directed curriculum if one were introduced in future.

Chart 14. Overall Impression of MicroSim Program



Chapter 6 - Conclusions and future work

This study, despite the small final sample size, goes some way towards showing that screen-based simulators such as Laerdal MicroSim can be a valuable addition to the ACLS teaching process. Use of the program as an adjunct to the textbook does not seem to make any significant difference either way to the theoretical knowledge or skills of the candidates but the program is very well received by the candidates and, for those who enjoy learning by computers, it provides a fun and novel way of learning ACLS.

While this study focused on the program as an adjunct to the textbook while preparing for the 2-day course, the direction being taken in the USA is to provide the option of replace the 2-day course with the program AND the textbook. Definitively establishing whether the program plus textbook is better than the 2-day course would require a considerable investment of resources on the part of both the ACLS providers (to be tested outside of the course time, before and after certification) and by the instructors (to test the candidates in a detailed manner, likely by video analysis outside of their own work hours).

Of course, the evaluation of the program in this way is a moot point in Ireland and the UK, since the self-directed curriculum is not available here. For the moment the program will continue to be available as worthwhile adjunct to the textbook.

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Appendix 1 - Questionnaires

Pre-Course Questionnaire

Evaluation of Laerdal MicroSim as an aid to learning ACLS

Pre-course Questionnaire

Thank you for taking the time to complete this questionnaire. It should take approximately 10 minutes. All information gathered will be anonymous and will be used solely for the purposes of this study.

General information about yourself.

What is your profession?

❒ Doctor Speciality:_____
❒ Nurse Area:_____
❒ EMT
❒ Other: _____

How many years have you been qualified?

❒ 1-2
❒ 3-4
❒ 5-10
❒ 10+

How often do you encounter acute cardiovascular emergencies in your everyday practice?

❒ Every Day
❒ Every Week
❒ Seldom
❒ Never

What is your age?

❒ 18-25
❒ 26-35
❒ 36-45
❒ 46-55
❒ 56-65
❒ 65+

Is English your first language?

❒ Yes
❒ No
Language:_____

Your previous experience of computer-aided learning

How do you access a Personal Computer (PC)?

- ❒ Work
- ❒ Home
- ❒ Other: _____

Is this computer connected to the internet?

- ❒ Yes (Broadband)
- ❒ Yes (Dial-up modem)
- ❒ Yes (Don't know the connection type)
- ❒ No

Does your computer have audio capability i.e. sound card and speakers?

- ❒ Yes
- ❒ No

What Operating system does your computer use?

- ❒ Windows XP
- ❒ Windows 98
- ❒ Windows NT
- ❒ Mac OS
- ❒ Other _____

Do you consider yourself "computer-literate" i.e. able to manage PC-tasks such as word-processing, internet-browsing and email, installing new programs?

- ❒ Very much able
- ❒ Average ability
- ❒ Unable, I always need help to do it.

Do you use this PC for educational purposes?

- ❒ Daily
- ❒ Weekly
- ❒ Less often
- ❒ Never

What educational resources do you access from your PC?

- ❒ CD-based programs e.g. simulators, quizzes, study aids.
- ❒ Medical Library e.g. Cochrane

❒ Medical Database e.g. Medline, CINAHL
❒ Other resources: _____
Details_____
_____
_____

How useful do you think these resources are?

❒ Always
❒ Sometimes
❒ Never

Have you ever used a computer program to learn ACLS before?

❒ No
❒ Yes
Name_____

Your expectations of ACLS computer program

Which do YOU feel is best way to learn ACLS? Please rank from 5 (best way) to 1 (worst way). Circle your answer.

ACLS Text book	Good	5	4	3	2	1	Bad
ACLS Instructor	Good	5	4	3	2	1	Bad
ACLS Simulator Program	Good	5	4	3	2	1	Bad
Real-Life Cardiac Arrest	Good	5	4	3	2	1	Bad

Which of the following do you think are important parts of a computer-aided learning program for ACLS? Circle your answer.

Multimedia Interface (sounds, pictures etc)	Important	5	4	3	2	1	Unimportant
Easy to install	Important	5	4	3	2	1	Unimportant
Easy to learn how to use	Important	5	4	3	2	1	Unimportant
Detailed feedback about your performance	Important	5	4	3	2	1	Unimportant
Links to further information e.g. to text book	Important	5	4	3	2	1	Unimportant
Includes all aspects of ACLS (rhythms, MI etc.)	Important	5	4	3	2	1	Unimportant
Variable level of difficulty	Important	5	4	3	2	1	Unimportant
Endorsed by Irish Heart Foundation/AHA	Important	5	4	3	2	1	Unimportant

Your previous ACLS experience

Have you done an ACLS Course before?

- ❒ Yes What Year? _____
- ❒ No
- ❒ Did not successfully complete.

Is ACLS certification a requirement for your post?

- ❒ Definitely required
- ❒ Desirable
- ❒ Not required
- ❒ Don't know

Do you intend to re-certify your ACLS every 2 years as required by IFH/AHA guidelines?

- ❒ Yes
- ❒ No

If part of your re-certification (e.g. MCQ, computer-based arrest scenario evaluations) could be done on your PC at home, would you prefer this way of re-certifying compared to a full 2-day course?

- ❒ Yes
- ❒ No

Reasons:_____
_____
_____

Your expectations of the ACLS Course

What are your reasons for doing ACLS? Tick those that apply.

- ❒ Required by my employer
- ❒ For clinical knowledge
- ❒ For confidence at cardiac arrests
- ❒ To pad out my CV

Which skills/knowledge do you think you will improve most by doing ACLS? Please rank from 1 (never done before), 2 (improve a lot), 3 (improve a little), 4 (I am quite competent at this already)

Basic Life Support	1 2 3 4
Rhythm recognition	1 2 3 4
Manual Defibrillation	1 2 3 4
Airway control	1 2 3 4
Intubation	1 2 3 4
ACLS Medications	1 2 3 4
Management of MI	1 2 3 4
Management of Stroke	1 2 3 4
Team leader at cardiac arrest	1 2 3 4

How do you find learning in a group situation?

- ❒ No problems
- ❒ Preferred method of learning
- ❒ Difficult to get attention
- ❒ Embarrassed by making mistakes

How much time (hours) do you expect to spend on each mode of learning before the course?

Reading the AHA Textbook	___
Using the program	___

Does your hospital/clinic have a Resuscitation Training Officer (RTO)?

- ❒ Yes, I have done some pre-ACLS study with him/her.
- ❒ Yes, but I have not met him/her yet.
- ❒ No.

Thank you for taking the time to fill out this questionnaire. Good luck with your ACLS course! After the course, you will receive another questionnaire which will allow you to give feedback about the aspects of the course the computer program (if you are part of the test group) which you found good, or bad.

If you have any questions or require further information about this trial or about ACLS, please contact me.

Thank you.

Post-Course Questionnaire

Post Course Questionnaire

Thank you for taking the time to fill out this questionnaire. I trust you enjoyed the ACLS course and learned a lot. These questions will allow you to provide feedback on the positives and negatives of the course and will give you an opportunity to voice your recommendations for future courses. Please elaborate as much as possible in your answers. It should take 5 to 10 minutes to finish. All information is anonymous and will be used solely for the purposes of my research.

Evaluation of ACLS Course

Quality of Material

How accurate did you feel was the information provided in the ACLS course?

- ❒ Accurate
- ❒ Out of date
- ❒ Inaccurate

Relevance to your workplace

Do you think that the skills learned on the ACLS course are relevant to your everyday practice?

- ❒ Yes
- ❒ No

Why? _____

_____

Quality of Instruction

Please rate your overall impression of the instruction received on the ACLS course. Please circle one number.

Clarity	Good 5 4 3 2 1 Bad
Consistency	Good 5 4 3 2 1 Bad
Feedback	Good 5 4 3 2 1 Bad
Rapport	Good 5 4 3 2 1 Bad

Group Learning

Did you find learning in a group situation easy?

- ❒ Yes
- ❒ No

Why? _____

_____

What factors do you feel influence your ability to learn successfully in a group situation?

Embarrassed by mistakes	Strong influence 5 4 3 2 1 No Influence
Judgement by Peers	Strong Influence 5 4 3 2 1 No Influence
Lack of attention	Strong Influence 5 4 3 2 1 No Influence

The MCQ at the end of the ACLS course is designed to test your theoretical knowledge. Do you feel that the 2-day course material to prepared you for the test?

❒ Yes
❒ No
Why? _____
_____

Please rate the Acute Coronary syndromes lecture by circling the appropriate number.

Clear	Very 5 4 3 2 1 Not at all
Relevant	Very 5 4 3 2 1 Not at all
Informative	Very 5 4 3 2 1 Not at all
Interesting	Very 5 4 3 2 1 Not at all

Please rate the Stroke Management lecture by circling the appropriate number.

Clear	Very 5 4 3 2 1 Not at all
Relevant	Very 5 4 3 2 1 Not at all
Informative	Very 5 4 3 2 1 Not at all
Interesting	Very 5 4 3 2 1 Not at all

Do you feel that large group lectures are a good way to cover the subjects of Acute Coronary Syndromes and Stroke Management?

❒ Yes
❒ No
Why?_____
_____

Skills Stations

Some people feel that the 2-day course is too information-intensive and does not allow them time to digest the information. Do you agree?

❒ Yes
❒ No
Why? _____
_____

Some people find that the 2-day, group-based ACLS course does not provide enough time to practice managing various cardiac arrest scenarios. Do you agree?

❒ Yes
❒ No
Why? _____
_____

Evaluation of Computer Program

Installation

Did you find the program easy to install on your computer?

- ❒ Yes
- ❒ No

Problems: _____

_____

_____

If you did have problems, were they fixed by consulting the help files?

- ❒ Yes
- ❒ No

User Interface

Was the user interface what you expected?

- ❒ Yes
- ❒ No

How intuitive (naturally easy to use) was it?

- ❒ Intuitive
- ❒ Required some practice to get used to it
- ❒ Difficult to use

Did you find the tutorial helpful in teaching you how to use the user interface?

- ❒ Yes
- ❒ Incompletely
- ❒ No

Did you find the help files included in the program useful?

- ❒ Yes
- ❒ Incompletely
- ❒ No

The user interface allows you to choose actions by a number of methods. Which method did you use most?

- ❒ Click on the team member to give instructions.
- ❒ Click on the patient's body part to start intervention.
- ❒ Click on the piece of equipment to use it.
- ❒ Click on the text-based menu at the bottom of the screen.
- ❒ A combination of the above methods.

How easy/difficult was it for you to navigate your way through the program to the scenario you wanted?

- ❒ Easy
- ❒ Sometimes difficult
- ❒ Difficult

Match to Real World

How close to the real world were the scenarios presented?

- ❒ Very accurate
- ❒ Mostly accurate
- ❒ Mostly inaccurate
- ❒ Very inaccurate

Was the skill level of the scenarios appropriate to your level of real-world expertise?

- ❒ Yes
- ❒ No

Why?_____

_____

Were the pieces of equipment e.g. defibrillator, and procedures e.g. 12-lead ECG easily recognisable to you?

- ❒ Yes
- ❒ No

User control and freedom

How easy/difficult did you find the control mechanisms for the scenarios e.g. choosing a scenario and starting/pausing/finishing the scenario?

- ❒ Easy
- ❒ Sometimes difficult
- ❒ Difficult

Consistency and standards

Were the explanations of your mistakes at the end of the scenario helpful?

- ❒ Yes
- ❒ No

Why? _____

_____

How consistent with the textbook/algorithms was the feedback provided by the program?

- ❒ Very consistent with the course material
- ❒ Mostly consistent
- ❒ Mostly inconsistent
- ❒ Very inconsistent

Did the feedback from the computer program direct you to information in the textbook which you found useful and relevant to you?

- ❒ Yes
- ❒ Sometimes
- ❒ No

How relevant was practicing the scenarios on the computer to practicing the scenarios and being assessed in the scenarios on the ACLS course?

- ❒ Very relevant, helped me a lot
- ❒ Somewhat relevant
- ❒ Not really relevant
- ❒ Totally irrelevant, put me at a disadvantage

Do you find managing a cardiac arrest scenario easier on the computer simulator compared to on the ACLS course and in real life?

- ❒ Yes
- ❒ No

Why? _____

_____

Error prevention

How often did you make mistakes by choosing one action when you meant to choose another?

- ❒ Frequently
- ❒ Occasionally
- ❒ Rarely

How easy was it to undo your mistakes?

- ❒ Easy
- ❒ Somewhat difficult
- ❒ Difficult

Once you completed one scenario, was it easier to understand the user interface to complete the other scenarios?

- ❒ Yes
- ❒ No

Enjoyment

Did you enjoy using the program?

- ❒ Yes
- ❒ No

Why? _____

_____

Which did you enjoy most?

- ❒ Computer program
- ❒ Reading the ACLS textbook
- ❒ Participating in 2-day ACLS course.

Why? _____

_____

Future Plans

In future, this program may form part of a self-directed learning program i.e. you would complete the full computer program at home and then attend for a 1-day ACLS course, focusing on practical skills. Would you prefer to do your next ACLS course this way (compared to 2-day ACLS without computer program)?

❒ Yes
❒ No
Why? _____
_____

Would you recommend this program to your colleagues who are planning on doing an ACLS course? (It costs approx 100 Euro).

❒ Yes
❒ No
Why? _____
_____

Thank you for your valuable time and effort. The results of this research will be published as part of my MSc thesis in September and will be presented to the Irish Heart Foundation in November.

If you have any further questions or would like to request more information on any of the resources used in this trial, please contact me at the address below.

Neil Reddy
neil.reddy@gmail.com

Appendix 2 – Glossary of terms and abbreviations

Acute Coronary Syndromes: signs and symptoms caused by narrowing or blockage of one or more of the coronary arteries. Commonly referred to as a heart attack.

Acute Ischaemic Stroke: signs and symptoms caused by blockage of an artery supplying the brain. Commonly referred to as a stroke.

ACLS: Advanced Cardiovascular Life-Support

AED: Automated External Defibrillator – a battery powered device the size of a brick which automatically interprets the cardiac rhythm of a collapsed patient and, if it finds VF/VT, automatically charges up and defibrillates the patient via sticky pads applied to the patient's chest.

AHA: American Heart Association – charity which co-ordinates hospital and community training for cardiac emergencies in USA.

Bradycardia: a heart rate slower than 60/minute.

Cardiac arrest: a collapsed patient with no pulse and no breathing.

CCU: Coronary Care Unit. A specialised cardiac ICU.

CPR: Cardiopulmonary resuscitation – provision of artificial breathing and chest compression to a person in cardiac arrest.

Cricothyrotomy: Opening a patient's airway by passing a needle through the skin of the neck, into the lungs. Used if there is an obstruction in the airway above the neck e.g. a swollen tongue or foreign body.

Defibrillation: Used for treatment of Ventricular Fibrillation and Ventricular Tachycardia, it involves the passage of an electrical current through a patient's heart with the intention of temporarily stunning the muscle and allowing the patient's normal cardiac rhythm to return.

ECG: electrocardiogram. A readout of the electrical activity of the heart muscle obtained by placing electrodes on the patient's chest and connecting to a transducer. The output is typically analogue – printed on a strip of paper or displayed on a monitor screen.

EMT: Emergency Medical Technician – similar to a paramedic but with a narrower scope of practice. Currently Ireland has only EMTs, not Paramedics.

Endoscopy: passage of a fibre-optic camera into a patient's body part to enable diagnostic or surgical procedure be performed.

Endotracheal Tube: a plastic device, inserted into the patient's lungs to enable oxygen to be passed directly into the lungs. It should be inserted by an expert.

ERC: European Resuscitation Council – responsible for hospital and community training for cardiac emergencies in UK and some European countries.

GPT: General Professional Training – general training undertaken by all junior doctors in the first 3 years after graduation.

ICU: Intensive Care Unit. A specialised hospital ward for management of critically-ill patients only.

IHF: Irish Heart Foundation – registered charity which co-ordinates hospital and community training for cardiac emergencies in Ireland.

ILCOR: International Liaison Committee On Resuscitation – international body which functions as a middle-ground between the various national Resuscitation bodies e.g. AHA, ERC, IHF

Laparoscopy: surgery performed by passing an endoscopic camera and instruments into a patient's body cavity. It is also referred to as minimally-invasive surgery or "keyhole" surgery.

MCQ: Multiple-choice questions

Needle thoracostomy: relieving excess air pressure around the lungs by passing a needle through the skin of the chest into the lungs. Used as an emergency procedure for certain types of collapsed lung (tension pneumothorax)

Oropharyngeal Airway: a plastic device which holds the tongue away from the back of the mouth, allow oxygen to pass to the lungs unhindered.

Paramedic: an emergency responder, typically working in a pre-hospital environment e.g. on ambulances, helicopters who has a narrower scope of practice than a doctor but can still perform many life-saving procedures.

Respiratory arrest: a collapsed patient with a pulse, who is not breathing.

SPR: Specialist Registrar – doctor who is on a training scheme to become a specialist.

Tachycardia: a heart rate faster than 100/minute.

Ventricular Fibrillation: a very common cardiac arrest rhythm. Treated by defibrillation when the patient has no pulse.

Ventricular Tachycardia: a very common cardiac arrest rhythm. Treated by defibrillation when the patient has no pulse.

Appendix 4 - Skills Assessment Sheets

American Heart Association®
Learn and Live℠

Mega-VF: Refractory VF/VT

Student Name [redacted] Date 28/8/15

	Check When Complete	Student action
Primary Survey		Uses Personal Protective Equipment / deal with breathing before using onto circulation
	✓	Performs ABCs; starts chest compressions and ventilations
	✓	Attaches AED or quick-look paddles or ECG monitor
	✓	Recognizes ECG rhythms of VF and pulseless VT
	✓	Delivers countershocks safely, effectively, and at correct energy levels
Secondary Survey	✓	Attempts advanced airway, using instruments correctly and safely (use Airway Management Skills Check sheet)
	✓	Establishes IV access using correct anatomic location and sterile techniques
	✓	Selects adrenergic agent; gives at proper dose and intervals Agent chosen: epi
	✓	Provides defibrillation after adrenergic agent but before antiarrhytmics
	✓	Consider antiarrhythmics; chooses proper agent dose and sequence Antiarrhythmic chosen: lignocaine
	✓	Considers likely causes of problem; develops differential diagnosis
	✓	Acts on differential diagnosis when reasonable
	✓	Proceeds to algorithm for the identified rhythm Rhythm identified: VF
	✓	Reassesses patient frequently
	✓	Interacts professionally and positively with family members and friends and with other healthcare professionals

Comments Quite good — deal c breathing prior to moving onto circulation
Check for pulse before BLS

Instructor signature [signature]

Instructor printed name [redacted]

ACLS Provider Candidate [redacted] / ANGELA GILSENAN

ACLS Instructor / BRIAN LAMONT

American Heart Association®
Fighting Heart Disease and Stroke

Case 3: Mega-VF: Refractory VF/VT

Critical Actions for ACLS Providers	Satisfactory	Needs Remediation
Primary ABCD Survey		
■ Assesses responsiveness	☑	☐
■ Calls for help	☑	☐
■ Calls for AED	☑	☐
■ Starts ABCs of CPR (uses pocket face mask)	☑	☐
■ Attaches AED, quick-look paddles, or ECG monitor	☑	☐
■ Recognizes ECG rhythms of VF and pulseless VT	☑	☐
■ Delivers countershocks safely, effectively, and at correct energy levels	☑	☐
Secondary ABCD Survey		
■ Prepares to achieve advanced airway control[1-1, 1-2]	☑	☐
■ Selects and prepares the LMA[3-1] ETT	☑	☐
■ Inserts LMA effectively and safely ETT	☑	☐
— Within 30 seconds	☑	☐
— Recognizes when taking too long	☑	☐
— Knows to try another airway method if unsuccessful or taking too long	☐	☐
■ Confirms LMA placement with these techniques[3-2]	☑	☐
— Uses end-tidal CO_2 device (qualitative or quantitative)[3-2]	☑	☐
— Performs 5-point auscultation	☑	☐
— Looks for chest expansion, rising O_2 saturation levels, vapors in tube	☑	☐
■ Secures tube in place: uses commercial holder, knows a taping technique	☑	☐
■ Checks clinical responses to confirm effective oxygenation and ventilation	☑	☐
■ Establishes IV access to circulation in correct location, with correct technique	☑	☐
■ If using LMA, does *not* consider drug administration through LMA	☐	☐
■ Considers tracheal drug route if using TT and IV access is unavailable	☐	☐
■ Selects adrenergic agent; gives at proper dose and intervals (gives more defibrillatory shocks *after* adrenergic agent *but before* antiarrhythmics)[3-3]	☑	☐
■ Rechecks rhythm; makes proper identification; defibrillates if indicated	☑	☐
■ Determines the VF pattern: persistent or recurrent?[3-4]	☑	☐
■ Considers antiarrhythmics; chooses proper agent, dose, and sequence	☑	☐
■ Considers likely causes of problem; develops differential diagnosis	☑	☐
■ Acts on differential diagnosis when reasonable	☑	☐

pulse checks
Recognized PEA and called correct treatment.
GJ 26/7/05

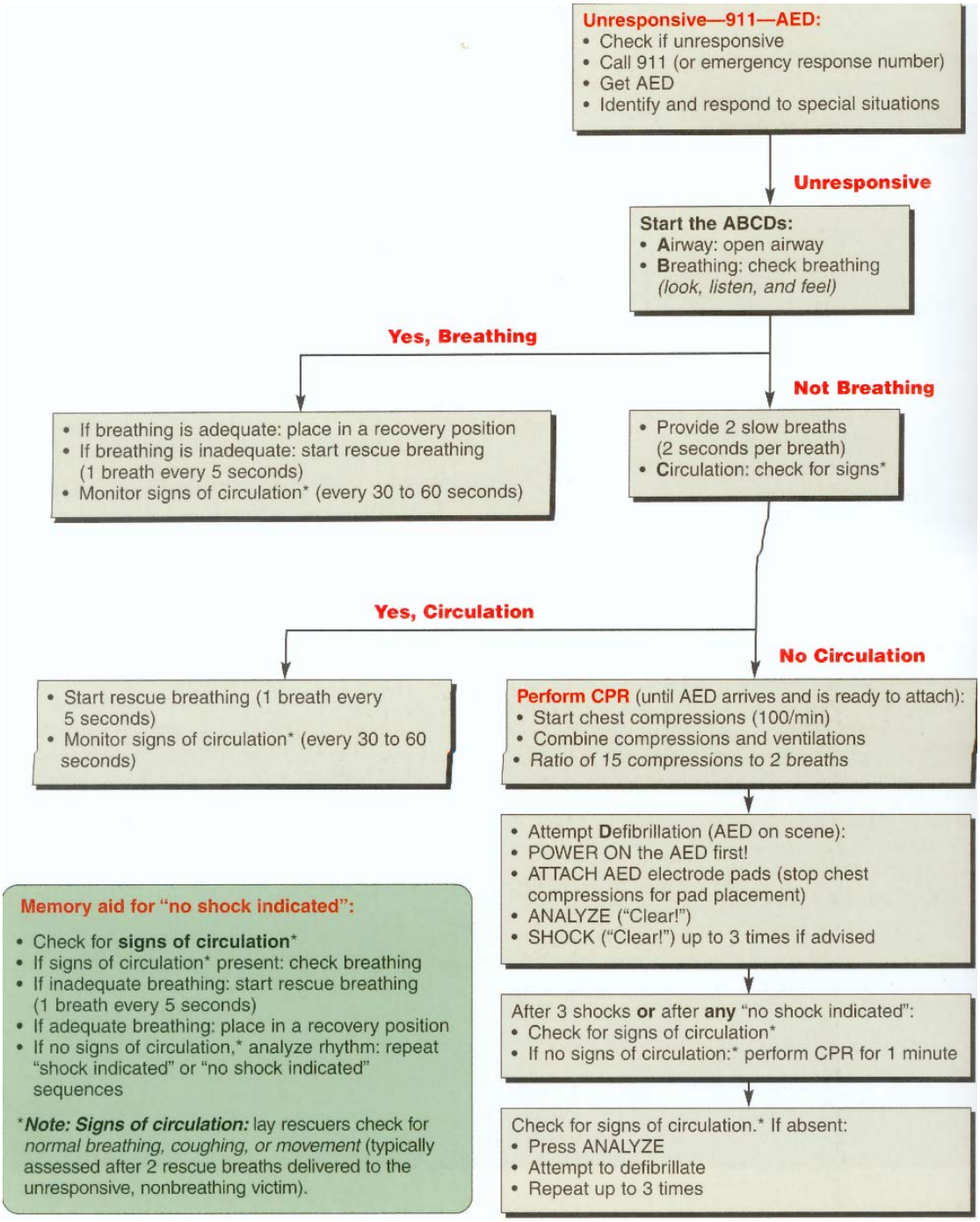
Appendix 4 - Sample MCQ Questions

A cardiac arrest victim in ventricular fibrillation has had 3 biphasic shocks of 150J with no change in rhythm. He has been intubated and ventilated with 100% oxygen. Chest compressions are being performed satisfactorily. What is the next most appropriate intervention?

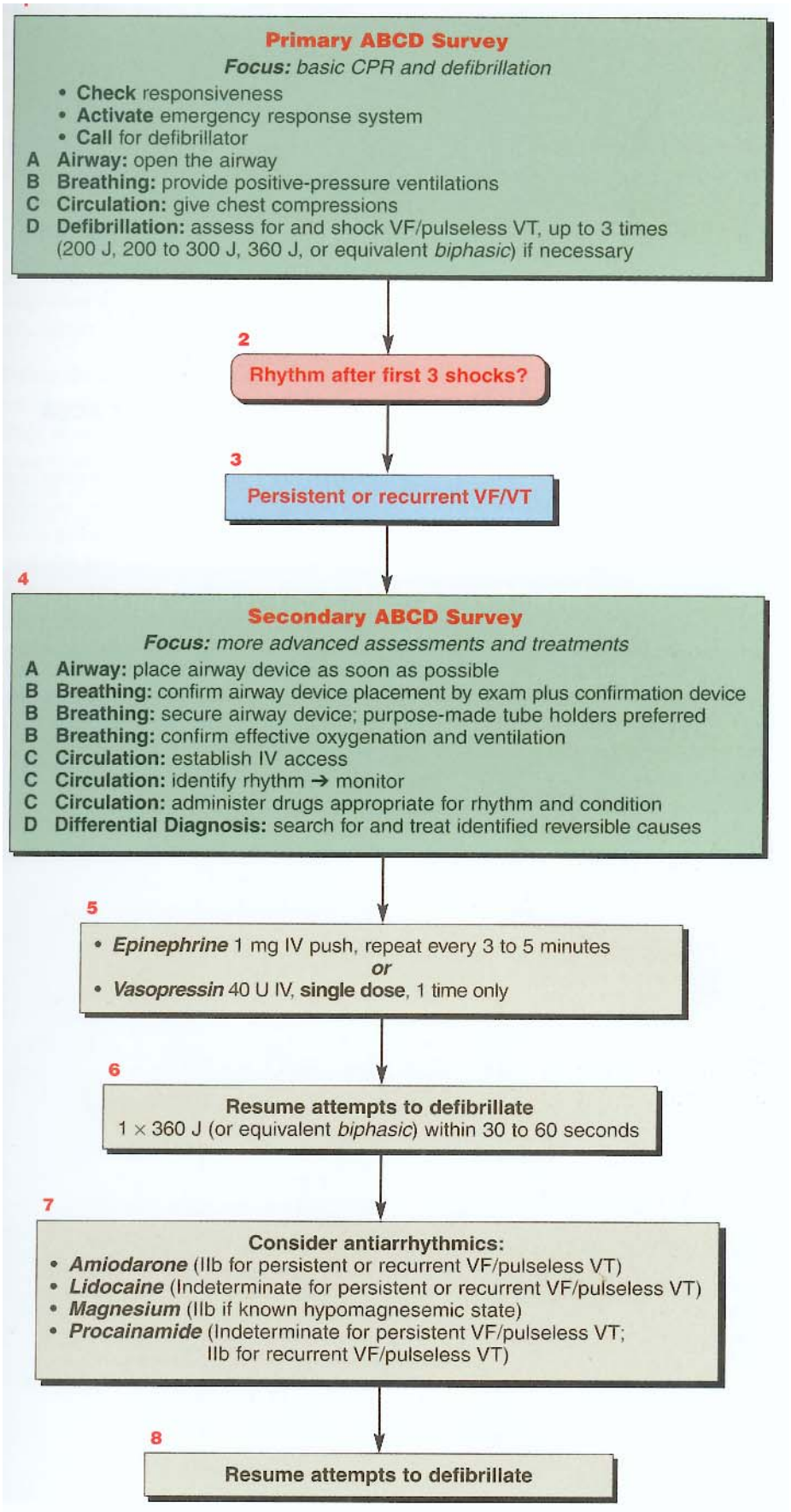
A. Place an IV line and administer amiodarone 150mg bolus dose.
B. Commence transcutaneous pacing at a rate of 70 paces/min.
C. Place an IV line and administer 1mg adrenaline with a 20ml flush.
D. Administer 1mg adrenaline via ET tube and flush with 20ml saline.

Appendix 5 – ACLS Algorithms

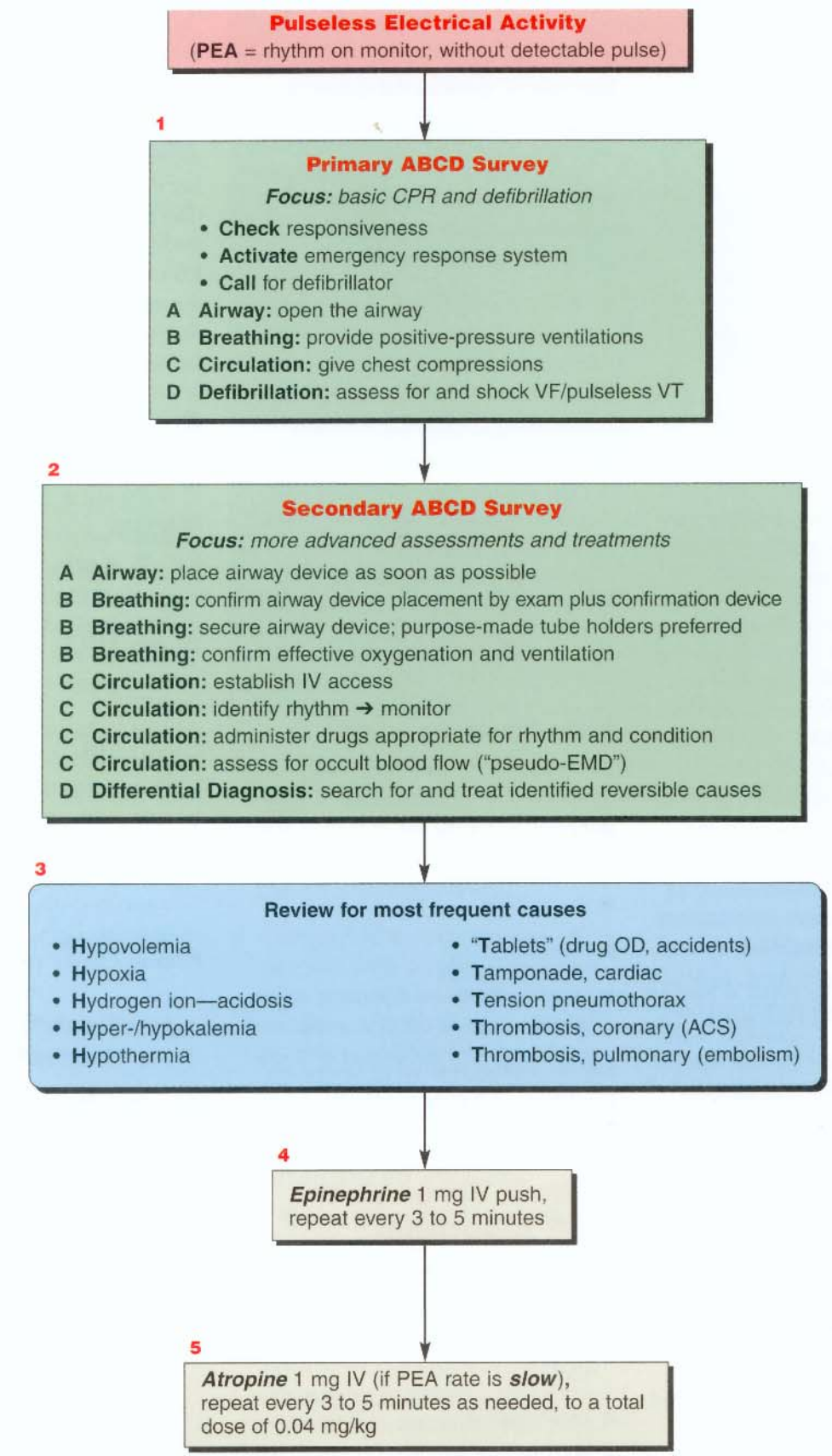
AHA ACLS Algorithm - Ventricular Fibrillation/Ventricular Tachycardia with BLS and AED



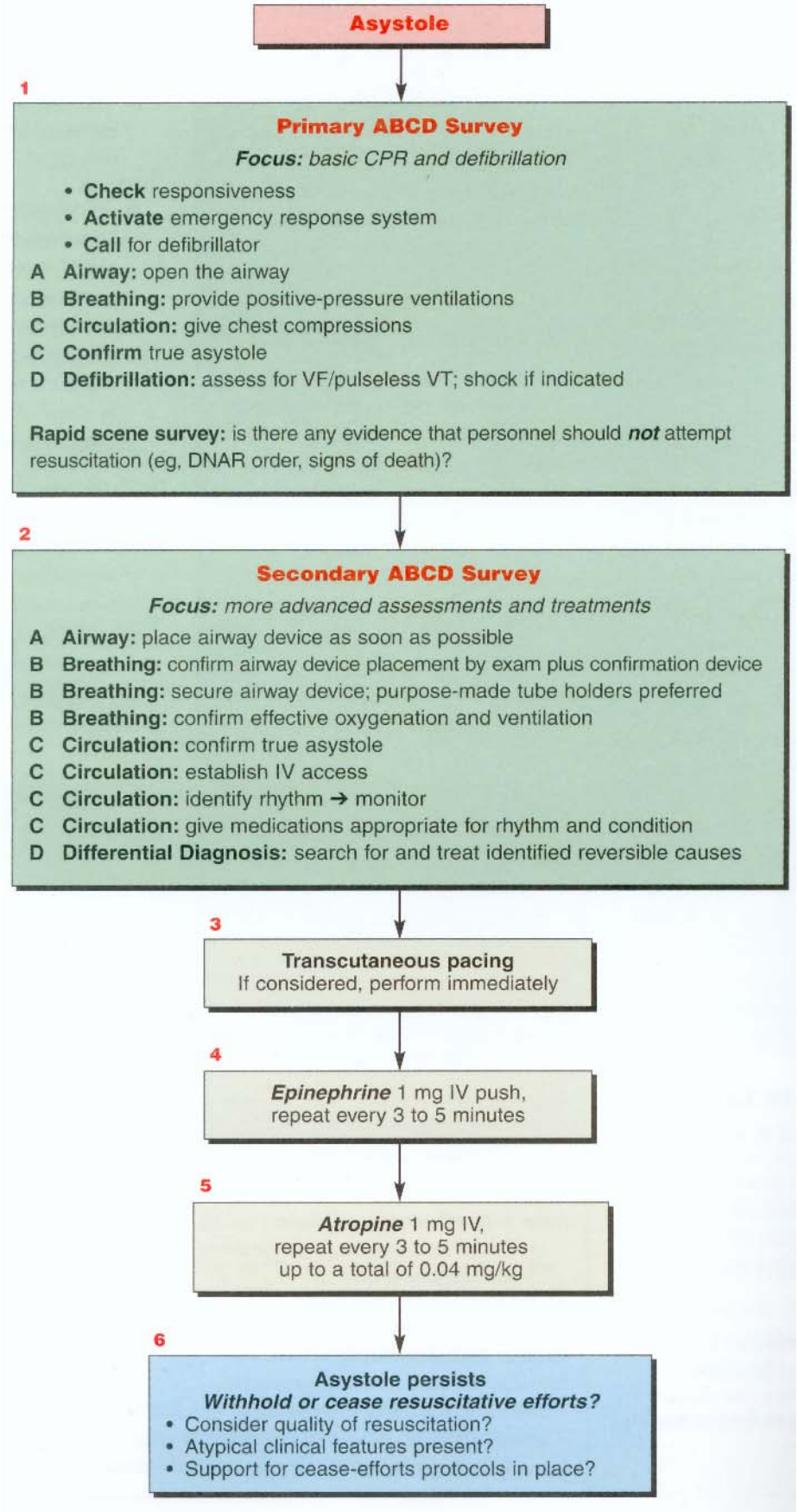
AHA ACLS Algorithm - Ventricular fibrillation / Ventricular Tachycardia



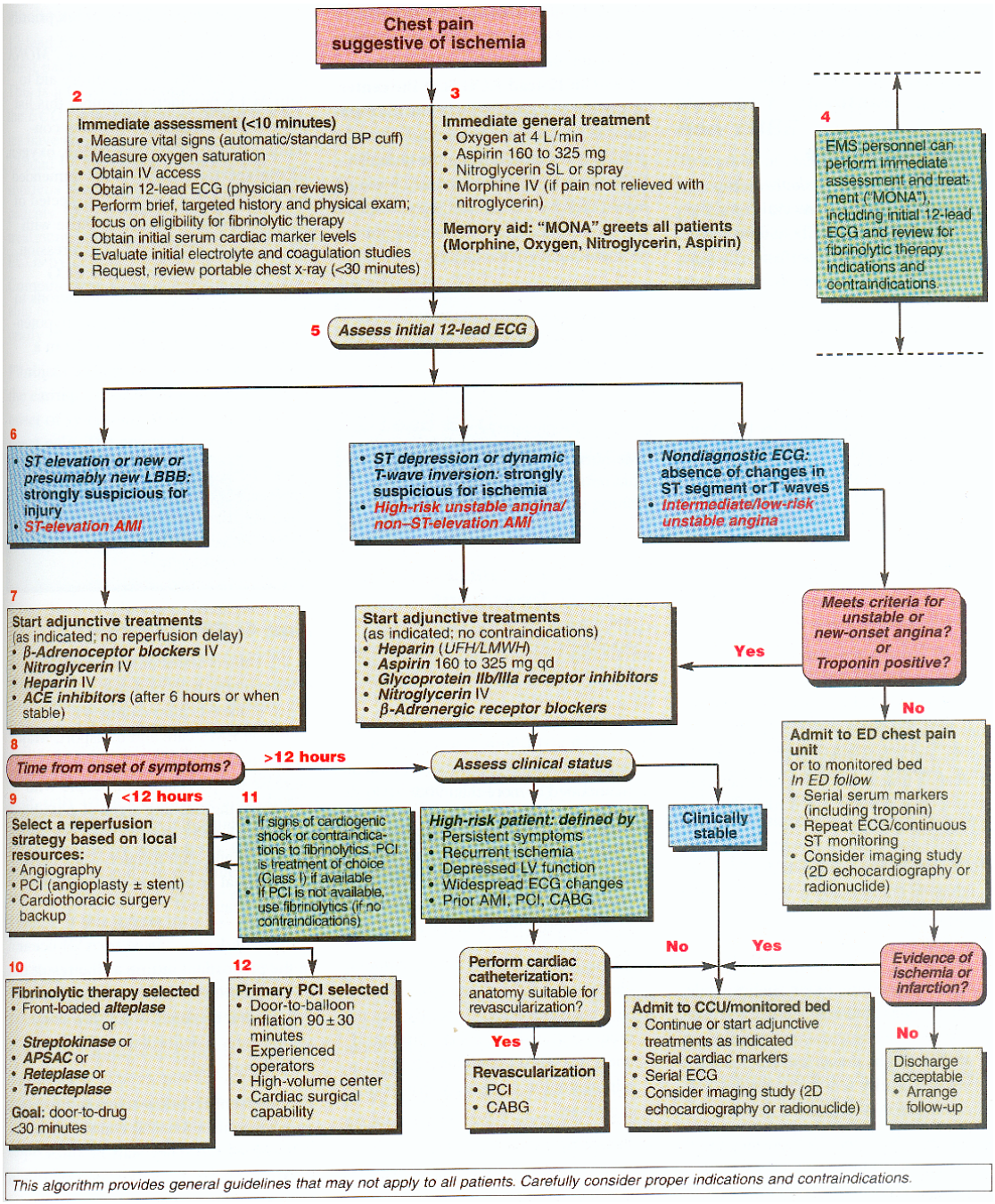
AHA ACLS Algorithm - Pulseless Electrical Activity



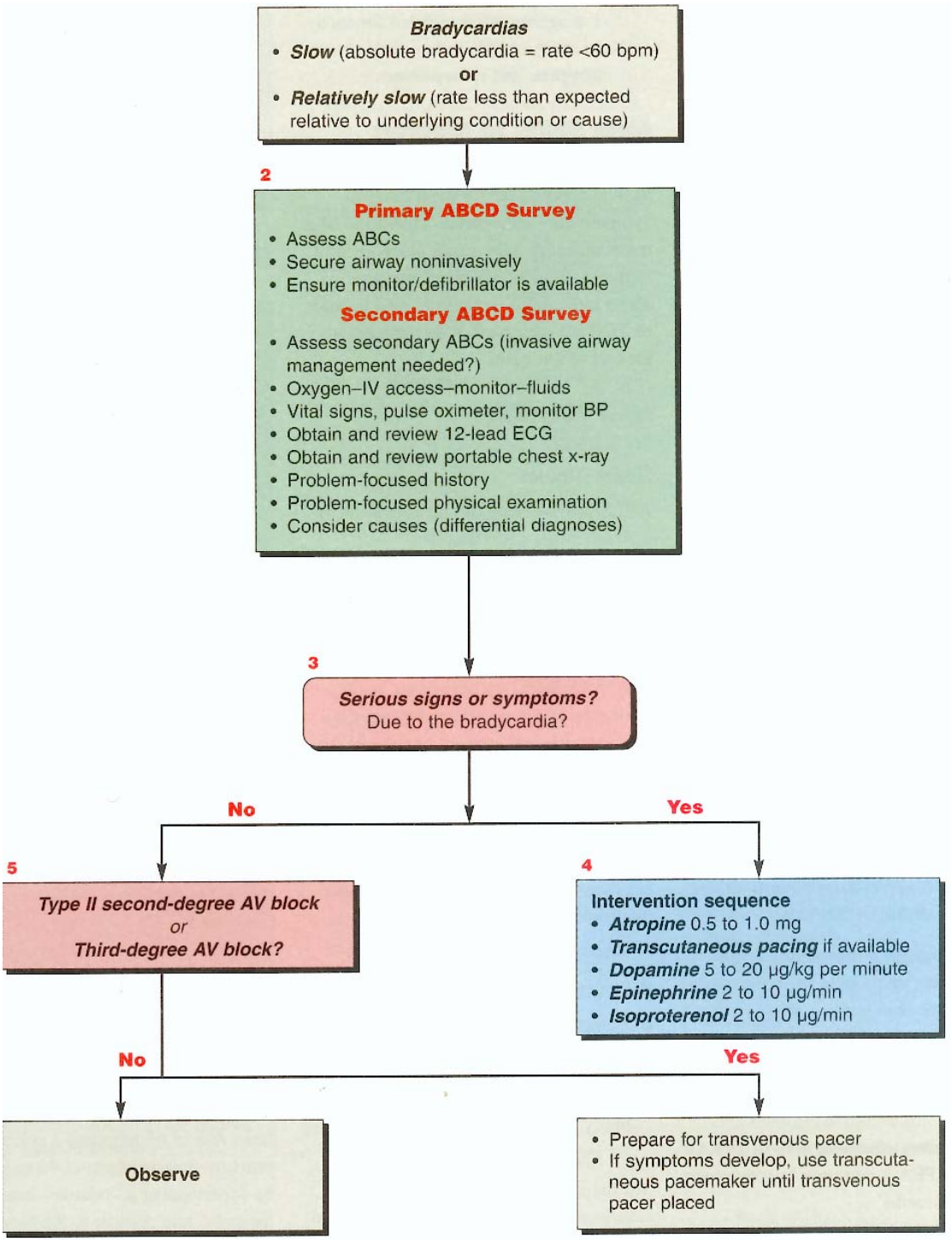
AHA ACLS Algorithm - Asystole



AHA ACLS Algorithm - Acute Coronary Syndromes

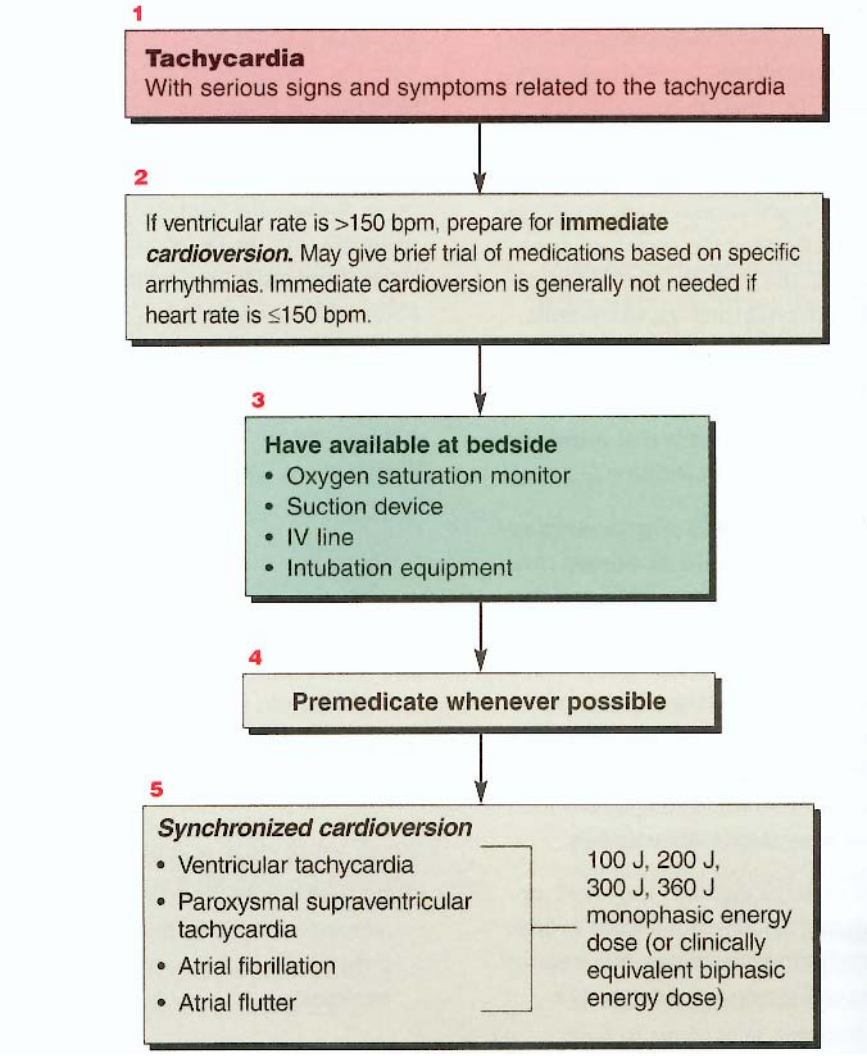


AHA ACLS Algorithm - Bradycardias

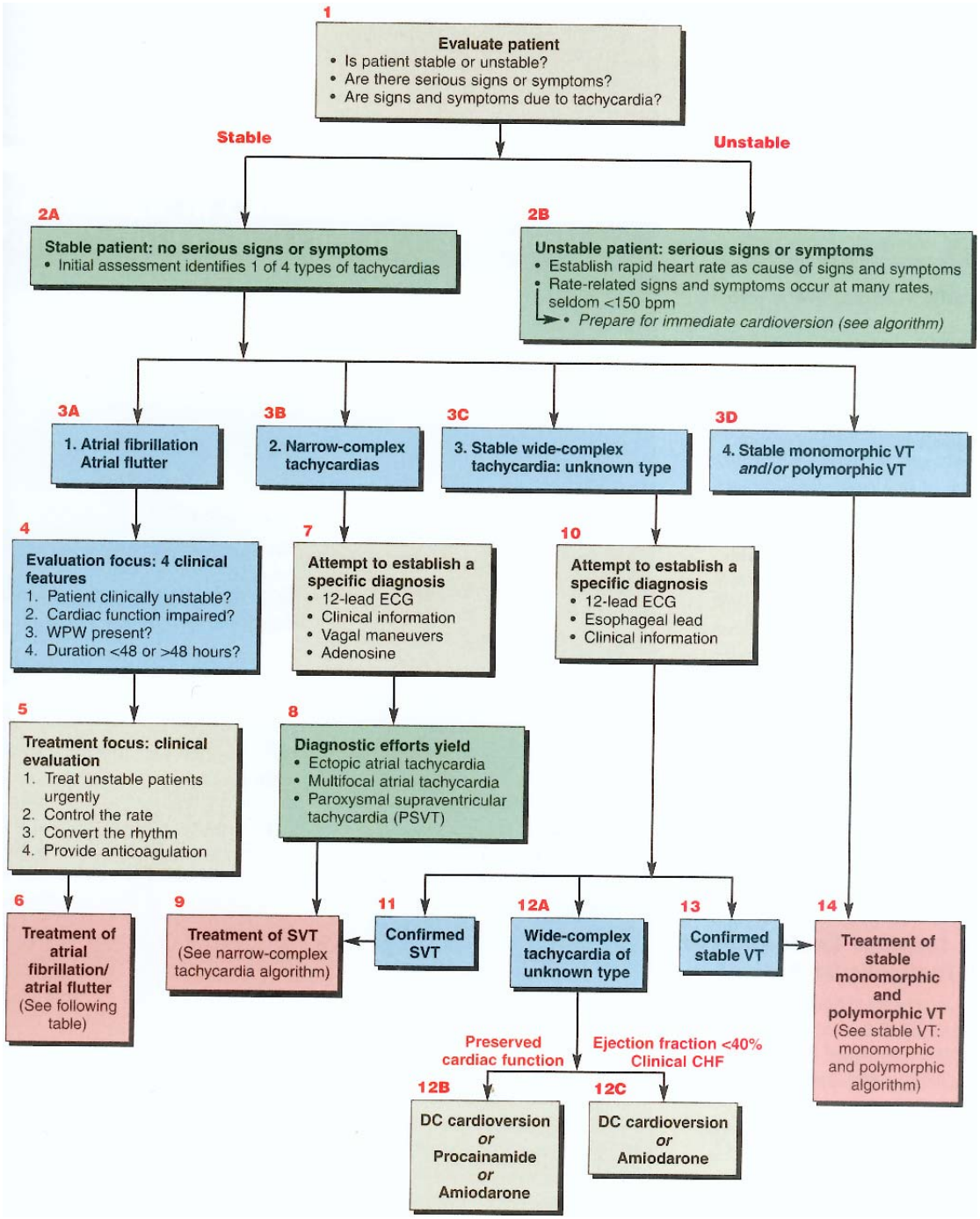


AHA ACLS Algorithm - Unstable Tachycardias

A Walk Through the Unstable Tachycardia Algorithm: Electrical Cardioversion



AHA ACLS Algorithm - Stable Tachycardias



AHA ACLS Algorithm - Management of Acute Ischaemic Stroke