IMPROVING THE QUALITY OF RESUSCITATION CARE

Gheorghe Ciobanu – PhD, The Department of Emergency Medicine, State University of Medicine and Pharmacy „Nicolae Testemiţanu", National Scientific Practical Center of Emergency Medicine, Chisinau, Republic of Moldova

Tel.:+ 373 22 23-78-84, E-mail: anticamera@urgenta.md

Summary

Sudden cardiac arrest is one of the leading causes of mortality in the hospital as well as in the community setting. Poor quality cardiopulmonary resuscitation (CPR) is believed to be a significant factor in the observed low survival rates, since multiple studies have documented a several-fold survival benefit of well-performed CPR. A number of studies have shown the importance of starting CPR as soon as possible after the onset of sudden cardiac arrest, given that survival falls 10-15% for every minute in which cardiac arrest care is not initiated. An important approach for immediate CPR education is the use of emergency telephone dispatchers to provide instructions to lay witnesses at the scene of a sudden cardiac arrest. A Japanese investigative group performed a prospective, multicenter, observational study of 4068 adult out-of-hospital cardiac arrests. The group showed that 10.8% of patients received compression-only resuscitation, 17.5% received conventional CPR, and 71.7% received no bystander CPR. Another real-time method to improve resuscitation quality is the provision of audiovisual feedback of any deviations from resuscitation guidelines, either via a freestanding CPR-sensing device or a defibrillator outfitted with CPR-sensing technology. The Inspiratory Impedance Threshold Valve is a small device placed at the end of the endotracheal tube or face mask during CPR delivery. It is used to prevent inflow of respiratory gases during active decompression (when the chest wall recoils) while the patient is not being actively ventilated to augment the negative intrathoracic pressure and, therefore, amplify venous blood return to the right heart. More recent small human trials demonstrated improved systolic blood pressures during a sudden cardiac arrest and improved short-term survival rates. A number of mechanical CPR devices have been developed in an attempt to overcome suboptimal chest compressions and CPR interruptions during manual delivery. One of the newer of these devices is a battery-powered compression band that is applied across the anterior chest wall and affixed via a backboard (Autopulse, Zoll Medical Corporation, Chelmsford, MA). LUCAS is a gas-driven sternal compression device that incorporates a suction cup for active decompression. The report of the first 100 consecutive cases treated with LUCAS during out-of-hospital sudden cardiac arrest documented that the 30-day survival was 25% in the setting of ventricular fibrillation and 5% in asystole if the CPR was started within the first 15 minutes from cardiac arrest [34] - these survival characteristics are similar to when conventional CPR is performed in the study locale. An important area that may yield improvements in CPR quality is that of improvements in human factors and resuscitation skills. In the medical domain, simulation methodology has historically focused on resuscitation, and many different tools are now being employed and developed, ranging from on-line simulation to integrated clinical simulators that use high-fidelity whole body manikins. Various different CPR techniques have received attention over the past few years. For example, one research group recently investigated whether CPR quality could be augmented by providing sustained abdominal pressure using an inflatable contoured cuff device on pigs during CPR after inducing ventricular fibrillation.

Key words: improving the quality, resuscitation care

Rezumat. Îmbunătăţirea calităţii a resuscitării

Calitatea nesatisfăcătoare a resuscitării cardiopulmonare este considerată a fi factorul principal al numărului mic de supravieţuitori în studiile observaţionale. Majoritatea studiilor ne argumentează importanţa aplicării prompte a resuscitării cardiopulmonare după stopul cardiac, supravieţuirea micşorându-se cu 10-15% cu fiecare minută de întârziere a iniţierii măsurilor de resuscitare. Un studiu prospectiv, multicentric efectuat de un grup de cercetători japonezi au analizat 4068 cazuri de stop cardiac în afara spitalului. Grupul a constatat că 10,8% au primit resuscitare primară numai prin compresiuni toracice, 17,5% au primit resuscitare cardiopulmonară deplină şi, 71,7% au primit primele măsuri de resuscitare cardiopulmonară de la persoane din afara sistemului de medicină urgentă. Un mijloc important de educaţie pentru aplicarea imediată a resuscitării de persoane din afara sistemului de urgenţă este utilizarea telefonului dispeceratului pentru instruire a persoanelor până la sosirea echipajelor de urgenţă. O altă metodă de ameliorare a calităţii resuscitării este asigurarea cu echipamente audiovizuale de informare în caz de deviere de la standarde şi ghiduri care sunt integrate în defibrilatoare. În ultimii ani au fost elaborate şi testate mai multe tehnici şi dispozitive de resuscitare cardiopulmonară. Valva cu prag de impedanţă (impedance threshold device; ITD) este un dispozitiv mic plasat la capătul tubului endotraheal sau la masa facială în timpul resuscitării cardiopulmonare. Dispozitivul limitează intrarea aerului în plămâni în timpul fazei de decompresie toracică, acest proces scade presiunea intratoracică şi creşte întoarcerea venoasă a sângelui către inimă. O recentă meta-analiză a arătat un efect pozitiv asupra restabilirii circulaţiei spontane şi supravieţuirii. În ultimii ani au fost elaborate mai multe dispozitive de resuscitare cardiovasculară mecanice în scopul asigurării compresiunilor eficiente şi minimalizării pauzelor în compresiunile toracice. Unul din aceste dispozitive este Autopulsul. Este un dispozitiv circumferenţial de compresie toracică, care include o bandă constructivă acţionată pneumatic şi o placă regidă. LUCAS

RCP (Lund University cardiac arrest system). Este un dispozitiv de compresie sternală, acţionat cu gaz, care incorporează şi o cupă de sucţiune pentru decompresie activă. Primele 100 de cazuri de moarte subită tratate cu LUCAS în prespital au raportat o supravieţuire de 25% la cei cu fibrilaţie ventriculară şi 5% la cei cu asistolie la 30 de zile, la care s-a intervenit în primele 15 minute de la stopul cardiac. Factorul uman şi nivelul profesional al tehnicilor de resuscitare sunt factori importanţi de îmbunătăţire a calităţii resuscitării cardiopulmonare. În domeniul medical metodele de simulare istoriceşte s-au focusat pe resuscitare şi astăzi sunt elaborate multiple modalităţi şi dezvoltate practici începând cu simulările on-line până la simulările clinice integrate cu utilizarea manichinelor sofisticate.

Cuvinte-cheie: îmbunătăţirea calităţii, resuscitarea cardiopulmonară

Резюме. Повышение качества реанимационных мероприятий

Неудовлетворительное качество сердечно-легочной реанимации считается основным фактором определяющим небольшое число выживших, согласно проведенных исследований. В большинстве научных работ утверждается важность оперативной сердечно-легочной реанимации после остановки сердца, т. к. выживаемость снижается на 10-15% с каждой минутой задержки начала реанимационных мероприятий. Проспективное многоцентровое исследование, проведенное группой японских исследователей, проанализировавших 4068 случаев остановки сердца за пределами медицинских учреждений, выявило факт, что в 10,8% реанимационные мероприятия были ограничены лишь компрессией грудной клетки, 17,5% получили полную сердечно-легочную реанимацию, а у 71,7% первичная сердечно-легочная реанимация проводилась лицами не относящимися к системе неотложной медицинской помощи. Один из важных средств обучения для непосредственного применения реанимационных мероприятий лицами не относящимися к системе неотложной медицинской помощи является использование телефонных консультаций с диспетчером до прибытия экипажей экстренной медицинской помощи. Другим способом повышения качества реанимационных мероприятий является предоставление аудиовизуальной информации интегрированной в дефибрилляторы, в случае отклонения от стандартов и алгоритмов. В последние годы были разработаны и испытаны многочисленные методы и устройства для проведения сердечно-легочной реанимации. Impedance threshold device, ITD представляет собой небольшое устройство помещающееся в конце эндотрахеальной трубки или поверхность лица во время сердечно-легочной реанимации. Ограничивая поступление воздуха в легкие во время фазы декомпрессии грудной клетки, этот процесс уменьшает внутригрудное давление и увеличивает венозный возврат крови к сердцу. Недавно проведенный мета-анализ показал положительное влияние данного эффекта на восстановление спонтанного кровообращения и выживания. В последние годы несколько устройств были разработаны для механической сердечно-сосудистой реанимации в целях обеспечения эффективного сжатия и уменьшая паузы в компрессиях грудной клетки. Одно из таких устройств является Autopuls. Это устройство, обеспечивает ритмичные сжатия грудной клетки и представляет из себя пневматически сжимаемую циркулярную конструкцию. LUCAS RCP (Lund University cardiac arrest system), устройство оказывающее компрессию на грудину с вакуум куполом для активной декомпрессии. После первых 100 случаев внезапной смерти на догоспитальном этапе, после применения устройства, LUCAS сообщили о 25% выживаемости у пациентов с фибрилляцией желудочков и 5% с асистолией в течение 30 дней, помощь которым было оказана в первые 15 минут после остановки сердца. Человеческий фактор и профессиональный уровень подготовки являются важными факторами для улучшения качества сердечно-легочной реанимации. В медицинской области разработаны несколько способов и методов профессиональной подготовки лиц для проведения сердечно-легочной реанимации, в том числе, он-лайн моделирование, интегрированное клиническое моделирование, использованием специальных маникенов.

Ключевые слова: повышение качества, сердечно-легочная реанимация

Introduction

Sudden cardiac arrest is defined as the cessation of mechanical cardiac activity as confirmed by the absence of signs of circulation [1]. Sudden cardiac arrest is one of the leading causes of mortality in the hospital as well as in the community setting. There are similar rates of sudden cardiac arrest in North America and Europe, leading to over 700,000 deaths in both regions combined annually [2-4] and, although overall cardiovascular mortality is decreasing, the proportion of deaths from sudden cardiac arrest has remained constant with a high mortality rate [5]. In fact, the survival rate from out-of-hospital sudden cardiac arrest has been reported to vary between 5 to 18%, depending on the original arrest rhythm and other factors [6].

Poor quality cardiopulmonary resuscitation (CPR) is believed to be a significant factor in the observed low survival rates, since multiple studies have documented a several-fold survival benefit of well-performed CPR [7-10]. Several studies have shown that the quality of CPR parameters - chest compression rate and depth, ventilation rate and fraction of time without chest compressions, for instance - often did not meet CPR consensus guideline recommendations [11]; this has been demonstrated during both in-hospital and out-of-hospital cardiac arrest.

The identification of deficiencies in CPR performance has led to recent changes in the international consensus CPR guidelines as promulgated by the International Liaison Committee on Resuscitation (ILCOR) [13]. Some of the more important of these recommendations focus on improving the quality of CPR by simplifying CPR instruction, increasing the number of chest compressions delivered per minute (by changing the compression-to-ventilation ratio from 15:2 to 30:2), and reducing interruptions in chest compressions during CPR. The guidelines also recommended continued emphasis on CPR education and quality improvement efforts to attempt to increase the survival of sudden cardiac arrest victims. These changes highlight the large potential to improve CPR quality. This chapter will review a variety of methods and new technologies that may play a role in achieving high quality CPR performance, and recent investigations using these methods will be discussed.

Improving outcomes from cardiac arrest requires high-quality care. Studies of both in- and out-of-hospital cardiac arrest show that there is a gap between what the guidelines say what actually happens in clinical practice. The aims of high-quality care are that care has to be safe, effective, patient-centred, timely, efficient and equitable. To achieve these aims, cardiac arrest care requires interventions at an international, national, local, team and individual rescuer level (**figure 1**).

A number of studies have shown the importance of starting CPR as soon as possible after the onset of sudden cardiac arrest, given that survival falls 10-15% for every minute in which cardiac arrest care is not initiated [14, 15]. Since professionals trained in Basic Life Support (BLS) or Advanced Cardiac Life Support (ACLS) are rarely the first responders at a sudden cardiac arrest, bystander CPR is an important determinant in providing prompt high quality CPR during out-of-hospital cardiac arrest.

The importance of high-quality cardio-pulmonary resuscitation

The performance of high-quality, uninterrupted

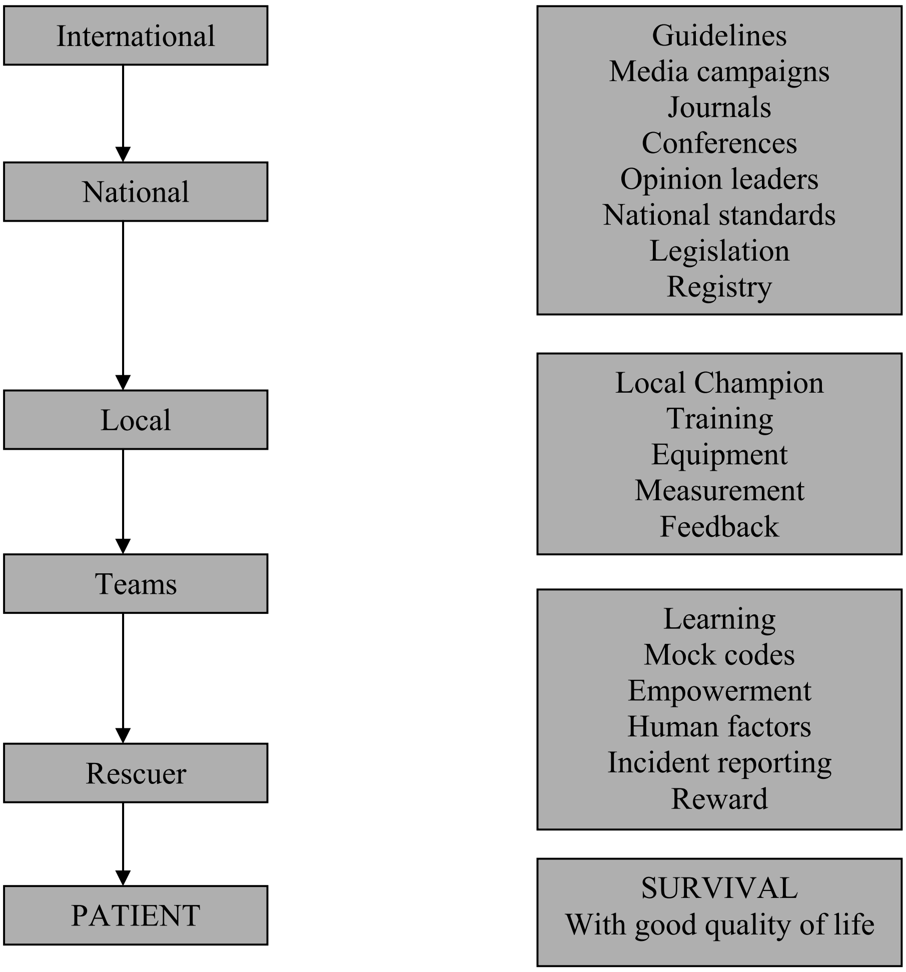

Figure 1. *Examples of quality improvement interventions*

chest compressions is an important determinant of outcome from cardiac arrest (**table 1, 2**).

Table 1

Characteristics of high-quality CPR

• Compression depth 5-6 cm • Compression rate 100-120 min^{-1} • Minimise interruptions in compressions • Ensure full chest re-coil between compressions • Avoid hyperventilation

Observational studies have shown that chest compression depth influences shock success, return of spontaneous circulation rates (ROSC) and survival. Higher chest compression rates are linked to improved ROSC. Similary, hyperventilation raises mean intrathoracic pressure, which reduces coronary perfusion and worsens outcome. CPR fraction (the proportion of resuscitation time spent performing chest compressions) is also a strong predictor of survival. Despite the prominence of CPR technique on outcome, observational studies provide consistent evidence of poor-quality CPR in clinical practice.

Table 2

Aims of high-quality care

Safe	Avoiding harm
Effective	Evidence based
Patient centred	Respectful care based on patient preferences, needs and values
Timely	Avoiding delays
Efficient	Avoiding waste
Equitable	Care quality does not vary according to issues such as race or socioeconomic status

Cardiopulmonary resuscitation feedback and prompt devices

Cardiopulmonary resuscitation feedback and prompt devices aim to improve the performance of resuscitation skills by CPR providers. Cardiopulmonary resuscitation feedback devices give information on the quality of CPR as it is performed, either through a visual display or audio instructions. Cardiopulmonary resuscitation prompt devices provide guidance to perform specific actions (e.g. sequence of CPR, audible beep for compression rate). The devices range in complexity from a simple metronome to an advanced defibrillator providing audio and visual feedback and prompts (**figure 2**).

Figure 2. *Simple CPR feedback/prompt device*

The more sophisticated devices assess CPR performance by measuring transthoracic impedance through defibrillation electrodes or through the use of an accelerometer (a small device placed on the sternum) or a combination of both. Measurement of transthoracic impedance enables chest compression rate, compression fraction and ventilation rate to be calculated. The addition of an accelerometer enables compression depth and completeness of release between compressions to be quantified (**figure 3**). Further methods to improve bystander instructions as well as novel mechanisms to improve lay public CPR, such as, for example, the use of automated external defibrillators (AEDs) with feedback capability for CPR performance, are being investigated.

Figure 3. *Sophisticated CPR feedback/prompt devices integrated with defibrillators*

A systematic review of the evidence for CPR feedback and prompt devices conducted as part of the International Liaison Committee for Resuscitation (ILCOR) review of resuscitation science in 2010, concluded that there is good evidence supporting the use of CPR feedback-prompt devices during CPR training to improve CPR skill acquisition and retention. Their use in clinical practice as part of an overall strategy may also be beneficial. The review highlights that accelerometers underestimate chest compression depth when CPR is performed on a soft surface such as a mattress as the do not differentiate between chest compression and mattress compression.

A large cluster randomized study in the US examined the use of CPR feedback technology in out of hospital cardiac arrest. Although CPR feedback technology improved CPR quality, there was no difference in ROSC rates or survival to discharge. However, baseline CPR performance and survival was higher than that observed in many communities, thus leaving limited opportunity for CPR process improvement to affect outcome. The time taken for rhythm analysis with an automated external defibrillator may have negated the effect of CPR quality improvement. Finally, the study investigated a single CPR feedback system. Whether other systems or the addition of post-event debriefing of emergency medical services (EMS) staff would influence outcomes remains to be determined. Further trials of CPR feedback technology during in- and out-of-hospital cardiac arrest are in progress.

Audiovisual Feedback Defibrillators

Another real-time method to improve resuscitation quality is the provision of audiovisual feedback of any deviations from resuscitation guidelines, either via a freestanding CPR-sensing device or a defibrillator outfitted with CPR-sensing technology. New defibrillators are capable of identifying and recording deficiencies in CPR quality and provide automated feedback to result in real time adjustment in CPR performance. These technologies had previously been studied in manikin simulations with encouraging results [26, 27], and recent investigations have compared resuscitation events using real time CPR detection and audiovisual feedback incorporated into a clinical monitor/defibrillator to those without feedback. The variability of multiple CPR parameters including chest compression rate and ventilation rate was decreased by providing real time feedback [28].

Telephone-directed Instructions

An important approach for immediate CPR education is the use of emergency telephone dispatchers to provide instructions to lay witnesses at the scene of a sudden cardiac arrest. However, the performance of bystander CPR even when being instructed over the telephone has been poor [16]. Examination of the deficiencies in bystander CPR led one group of investigators to modify telephone instructions used by a British dispatch service to emphasize key CPR parameters such as chest compression rate. The rate of chest compressions was improved but still below the recommended 100 per minute as recommended by ILCOR and the depth of chest compressions decreased to 2.0 cm [17]. This study highlights the complexity of telephone CPR instructions and their limitations to improve care.

Mobile phones

The now almost universal carriage of mobile smart phones positions them as a potentially useful adjunct for CPR practice. Applications that support initial training, feedback-prompts during resuscitation and audit of outcomes have been developed (**table 3** and **figure 4**).

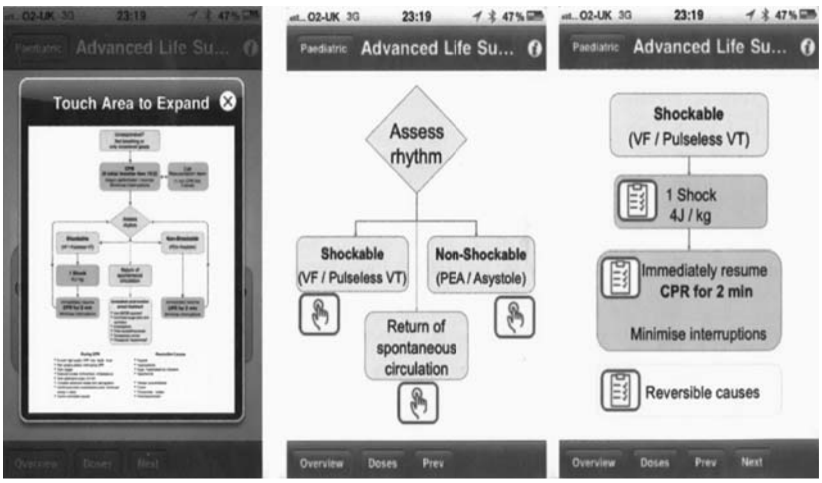

Figure 4. *The i-resus application contains the Resuscitation*

Table 3
Mobile phone technology can support each link of the chain of survival

Early access	**Early CPR**	**Early defibrillation**	**Post-resuscitation care and audit**
Call EMS	Adjunct to dispatcher CPR	Locate nearest AED	Checklists
Mobile phone tracking to locate patient	CPR feedback/ prompt instructions	Dispatch community AED response	Audit: transmit CPR quality data for review
Mobile phone tracking to detect nearest response		Monitor ECG	Audit: collate and submit code summaries
SMS to activate community responders			

Mechanical chest compression devices

Mechanical chest compression devices automate the process of chest compression. Advantages of mechanical CPR devices are the provision of consistent quality, non-fatiguing chest compressions and freeing up a member of the resuscitation team. Potential disadvantages are interruption during CPR to deploy the device, which may increase no flow time (the time without chest compressions) and the potential for chest/visceral injuries; however, these need to be considered in the context of overall survival (**table 4**).

Table 4
Potential advantages and disadvantages of mechanical CPR

- **Potential advantages**
  - Consistent quality of CPR
  - CPR quality does not fatigue
  - Releases a member of the resuscitation team from manual compressions
  - Shock delivery during chest compression
  - Can be deployed in confined spaces
- **Potential disadvantages**
  - Interruptions to CPR during deployment
  - Risk of chest wall and visceral injuries

A number of mechanical CPR devices have been developed in an attempt to overcome suboptimal chest compressions and CPR interruptions during manual delivery. Although these devices can reliably produce consistent compressions and eliminate the factor of human error, data regarding their clinical utility are conflicting at this point. Further investigation into mechanical CPR devices is needed to assess the appropriate use of these devices in resuscitation.

Active compression – decompression CPR

Active compression – decompression CPR (ACD-CPR) is achieved with a hand-held device that incorporates a suction cup that enables the chest to be lifted actively during decompression (**figure 5** and **6**).

Figure 5. *Active compression – decompression device*

Figure 6. *Combined used of active compression-decompression device and impedance threshold device*

The active decompression reduces intrathoracic pressure, which increases venous return to the heart, increases cardiac output and increases coronary and cerebral perfusion pressures during the compression phase. In some clinical studies ACD-CPR improved haemodynamics compared with standard CPR.

Autopulse

One of the newer of these devices is a battery-powered compression band that is applied across the anterior chest wall and affixed via a backboard (Autopulse, Zoll Medical Corporation, Chelmsford, MA). The Autopulse device consists of a load distributing band (LDB) that is placed around the chest and backboard. The LDB tightens around the chest and then loosens to allow passive decompression; this cycle occurs at 80 per minute. The device adjusts the LDB to the size of the patient and distributes the compressive load over the anterior chest. Animal and human studies show improved physiological parameters compared with manual CPR (**figure 7**).

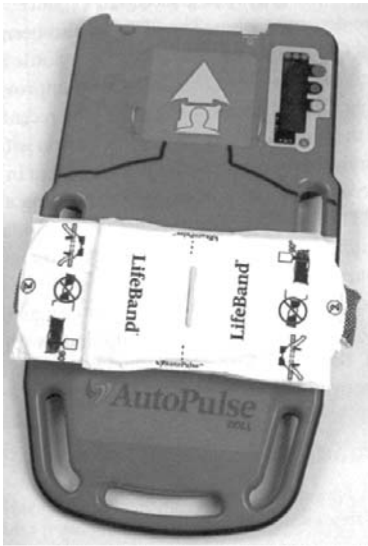

Figure 7. *Autopulse mechanical chest compression device*

The Autopulse has been examined in two large-scale randomized controlled trials. The ASPIRE trial showed worse neurological outcomes and a trend toward worse survival in the Autopulse arm compared to the manual CPR group. The follow-up trial (CIRC trial) compared Autopulse with manual CPR in CPR-optimized EMS systems. Early results indicate treatment with Autopulse led to similar outcomes to the manual CPR group. Further investigations into the appropriate use of Autopulse are needed to resolve these conflicting data.

Lund University Cardiac Arrest System (LUCAS)

LUCAS is a gas-driven sternal compression device that incorporates a suction cup for active decompression. LUCAS provides both chest compressions and active decompression. It consists of a silicon rubber suction cup that is applied to the chest and an electric motor mounted on two legs which are connected to a stiff back plate (**figure 8**).

Figure 8. *LUCAS-2 mechanical chest compression device*

The original LUCAS device was gas driven (oxygen/air) but has been superseded by a battery driven device (LUCAS-2). This development has overcome the logistical requirement to carry compressed gas to power the device and initial concerns about the development of high oxygen concentrations in confined spaces. The device compresses the chest between 4 and 5 cm at a rate of 100 compressions per minute with an equal amount of time being spent in compression and decompression. Animal and human studies have shown improved physiological parameters compared with manual CPR. Studies focusing on clinical outcomes have produced mixed-inconclusive results. While currently not approved by the Food and Drug Administration (FDA) for clinical use in the United States, LUCAS is currently approved and being used in Europe during clinical resuscitation. The report of the first 100 consecutive cases treated with LUCAS during out-of-hospital sudden cardiac arrest documented that the 30-day survival was 25% in the setting of ventricular fibrillation and 5% in asystole if the CPR was started within the first 15 minutes from cardiac arrest [34] - these survival characteristics are similar to when conventional CPR is performed in the study locale.

Compression-only Resuscitation

A major obstacle to effective resuscitation care is the lack of bystander participation - less than 25% of sudden cardiac arrest victims receive bystander CPR, which may be due to lack of training or unwillingness of trained individuals to perform CPR. Previous investigations have shown that some of the resistance of bystanders to performing CPR relates to the fear of mouth-to-mouth contact [18]. This has led to an interest in whether providing chest compressions only (without rescue ventilations) would be equally beneficial when compared with performing standard CPR with ventilations included [19-23]. A Japanese investigative group performed a prospective, multicenter, observational study of 4,068 adult out-of-hospital cardiac arrests where paramedics assessed bystander CPR on arrival at the scene. The technique of bystander CPR was compared to the primary endpoint of favorable neurological outcomes 30 days after cardiac arrest. The group showed that 10.8% of patients received compression-only resuscitation, 17.5% received conventional CPR, and 71.7% received no bystander CPR. Not only did any attempt at resuscitation result in more favorable neurological outcomes, but the compression-only resuscitation also resulted in a significantly higher proportion of patients with a favorable neurological outcome when compared to conventional CPR [24], Future studies will be required to determine whether compression-only CPR should be recommended for all bystander resuscitation care.

Device Adjuncts to Manual Cardiopulmonary Resuscitation

Given concerns regarding inadequate CPR performed by bystanders and trained first-responders, one simulation study aimed at improving layperson CPR quality by providing audio prompts incorporated into an AED. Twenty-four laypersons were asked to provide CPR on a manikin with and without audio prompts. The investigators demonstrated that performance levels met guideline criteria for CPR when an audio prompt was given to an untrained layperson and subjects felt more confident about the CPR they were providing [25].

Inspiratory Impedance Threshold Valve (ITV)

The ITV is a small device placed at the end of the endotracheal tube or face mask during CPR delivery. It is used to prevent inflow of respiratory gases during active decompression (when the chest wall recoils) while the patient is not being actively ventilated to augment the negative intrathoracic pressure and, therefore, amplify venous blood return to the right heart (**figure 9**).

Figure 9. *Impedance threshold device*

Early animal investigations showed improved 24 h survival and neurological recovery when an ITV

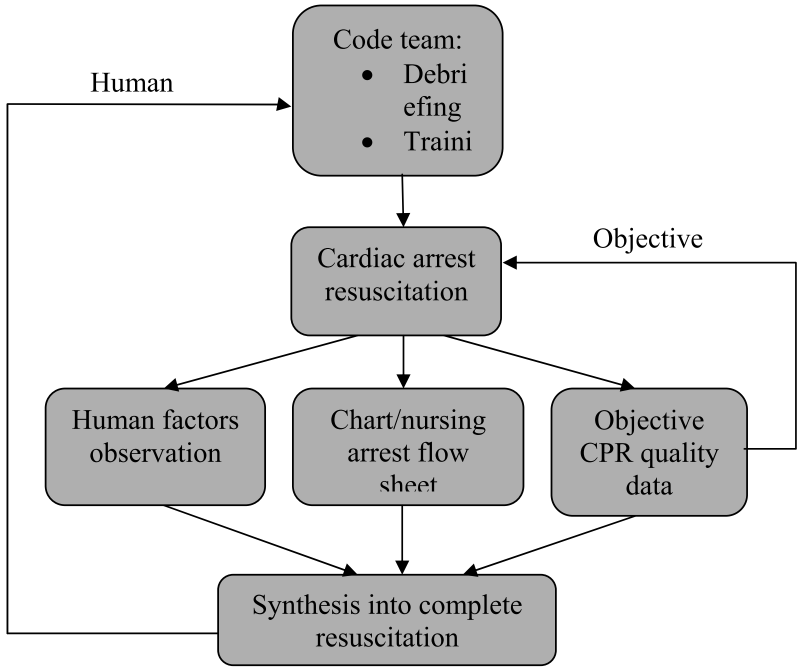

Figure 10. *Overview of cardiopulmonary resuscitation (CPR) quality improvement techniques and how they might fit into the framework of clinical resuscitation care. Note that this model involves two distinct feedback loops to improve quality - one relies on human feedback via education/debriefing, and the other depends on devices to provide objective information during or after a sudden cardiac arrest event*

was compared to a sham valve [29]. More recent small human trials demonstrated improved systolic blood pressures during a sudden cardiac arrest and improved short-term survival rates [30, 311].

Training and Education

An important area that may yield improvements in CPR quality is that of improvements in human factors and resuscitation skills. The lack of adequate resuscitation training and education for health care professionals was recently highlighted by a cross-sectional survey study. Of 289 Canadian medical residents who responded to a questionnaire on resuscitation skills confidence, almost half (49.3%) felt inadequately trained to lead cardiac arrest teams and over half (55.3%) expressed fear that that they may have made errors during past resuscitation care [35]. Only 5.9% reported having had received debriefing of any kind following a cardiac arrest and only 1.3% reported having obtained any feedback from colleagues or instructors. This survey highlights the need for further education in resuscitation - incorporating different techniques, including simulation, feedback, and debriefing. These tools can serve as an important component of resuscitation quality improvement, especially when coupled with robust data collection that can then feed into educational programs (**figure 10**).

Simulation

Given the trend towards reduction in exposure of physicians-in-training to critically ill patients in the United States, simulation and "mock codes" are being used more commonly to provide necessary instruction. In the medical domain, simulation methodology has historically focused on resuscitation, and many different tools are now being employed and developed, ranging from on-line simulation to integrated clinical simulators that use high-fidelity whole body manikins [36]. The Resuscitation Council in the United Kingdom and the European Resuscitation Council Advanced Life Support Provider course has now integrated simulation training [37], Incorporating simulation into advanced life-support training combines repetitive practice opportunities with multiple learning strategies while also providing feedback. One study measured the impact of medical simulator sessions on adherence to resuscitation guidelines by internal medicine residents. Those that had simulator training showed significantly better performance even after adjusting for clinical experience, which, by itself, had no impact on performance of advanced cardiac life support [38].

Simulation can also address and teach other skills that are necessary for a successful resuscitation, skills that are difficult to teach by mechanisms other than modeling or simulation. For example, a simulation study of 16 teams comprised of three health-care workers assessed whether the teams could successfully convert ventricular fibrillation to sinus rhythm by providing two shocks within the first two minutes or by two shocks during the first five minutes if uninterrupted basic life support was started within 60 seconds [39], Only six of the teams were successful. Several variables between the successful and the unsuccessful teams were compared including leadership, task distribution, information transfer, and conflicts. Although all teams demonstrated the necessary theoretical knowledge, the successful teams had significantly higher ratings of leadership and task distribution.

Debriefing

Following a sudden cardiac arrest, an important opportunity for learning exists among the participating health care providers. During the time immediately following a sudden cardiac arrest event, participants are primed to discuss and learn from the recent event. This provides a key moment to provide real-time and relevant verbal feedback to a provider of CPR. Studies have demonstrated that providing verbal debriefing can impact the quality of subsequent simulated cardiac events. In fact, even when combining real time audiovisual feedback as described earlier with debriefing using the data obtained from the CPR detection device, not only was CPR quality improved, but return of spontaneous circulation was significantly increased [40].

Other Cardiopulmonary Resuscitation Techniques

Various different CPR techniques have received attention over the past few years. For example, one research group recently investigated whether CPR quality could be augmented by providing sustained abdominal pressure using an inflatable contoured cuff device on pigs during CPR after inducing ventricular fibrillation. This resulted in a significant increase in coronary perfusion pressure throughout the duration of abdominal pressure and was immediately reversible upon deflating the device. The increase in coronary perfusion pressure was similar to that seen with vasopressor drugs [41]. Given this animal study and new information about the potential consequences of vasopressors, such as post-resuscitation myocardial depression, further investigation into sustained abdominal compression to enhance CPR may be warranted.

Conclusion

Sudden cardiac arrest is a major cause of mortality worldwide resulting in over 700,000 deaths each year in Europe and in the United States combined.

Studies have demonstrated improved outcomes when resuscitation care, and especially CPR, is well-performed. Therefore, given the presently dismal survival rate, further investigations to improve the quality of resuscitation are necessary. So far, methods to improve the training of bystanders as well as medical professions by providing real time audiovisual feedback during CPR performance have been most promising with a potential to increase the rate of return of spontaneous circulation. Innovative methods to teach CPR, such as integrating simulation into training classes or incorporating real-time audiovisual feedback, may enable better instruction to be given to health care providers. Several new mechanical devices have been developed in an attempt to eliminate human error from resuscitation events and allow the health care providers to focus on other aspects of the resuscitation. Through further investigation of such devices and methods of instruction, CPR quality during actual delivery may be improved in coming years, and this, in turn, will hopefully lead to improvements in saving lives from this enormous clinical problem of sudden cardiac arrest.

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