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An Elderly Man in Cardiac Arrest on a Ski Slope

Cardiac arrest remains 1 of the most prominent global health issues of our time. Despite continued research and evolutions in the treatment of cardiac arrest, successful resuscitation is often impossible. This article reviews 1 such case in which the patient, despite stacked odds against him, fully recovered from persistent ventricular fibrillation (VF) arrest with a prolonged downtime in a remote setting.

Case Report

Just after 0925, a rural emergency medical service team was activated. A few miles away at a local ski area, there were on-slope 911 reports of an unresponsive skier. The day was sunny with mild temperatures despite being just before New Year's Day in rural New England. Within minutes, the local ambulance responded. At the same time, the county dispatch alerted ski patrol. Updates from the scene confirmed a patient in cardiac arrest with cardiopulmonary resuscitation (CPR) in progress. Later reports confirmed that just after the 74-year-old male patient collapsed, a colleague and other passing skiers, including a physician and nurse, immediately initiated patient care. Eyewitnesses report that the fall was uneventful and atraumatic and that CPR was initiated in less than 1 minute. Ski patrol arrived soon thereafter, supplementing efforts with a bag valve mask and oxygen. This continued for approximately 20 minutes when a snowmobile arrived with an automated external defibrillator (AED) and paramedic/flight nurse from the local ambulance service.

The AED was applied, and a shock was delivered followed by immediate CPR. Two more shocks were delivered in the subsequent 5 minutes, the last approximately 27 minutes after the initial call for help. Intraosseous (IO) access was achieved by the paramedic, and 1 mg epinephrine was administered. Soon thereafter, the patient began spontaneously breathing while moving his arms and groaning. The AED reanalyzed and recommended that no shock was to be delivered. A weak carotid pulse was detected at that time; therefore, the patient was quickly packaged, and transport to the base area was initiated. During transport, the AED reanalyzed and advised for a fourth shock to be given. Transport was momentarily halted for the fourth shock but quickly reestablished until reaching the ambulance where care was continued to the local community hospital. En route, a peripheral intravenous line was established, and 150 mg amiodarone was administered in the setting of runs of ventricular tachycardia. Despite persistent ectopy, the patient maintained a pulse of ~100, blood pressure of 142/95, and oxygen saturations of ~98% on a nonrebreather.

Forty-five minutes after the initial 911 call, care was transferred to the local emergency department. Family arrived soon after the patient; at this time, it was noted that he had a history of hypertension, 3-vessel coronary artery bypass graft surgery 15 years prior, and 3 previous myocardial infarctions, all requiring stent placement with the most recent occurring 2 weeks earlier. The patient was intubated with standard rapid sequence induction because of continued altered mentation. Concurrently, a lidocaine drip of 2 mg/min was initiated, and air transport to a regional percutaneous coronary intervention (PCI) center was arranged. Initial cardiac markers were negative, and a 12-lead electrocardiogram showed ST depressions in V2-V6. A chest x-ray was completed and showed left fifth and sixth displaced rib fractures and atelectasis in the lung bases. Forty milligrams of furosemide was administered prior, and sedation was maintained with propofol. A rotor wing transport was arranged for transfer to a regional cardiac center, which was completed without complication.

On arrival, the receiving facility opted not to perform emergent PCI. An echocardiogram was completed revealing an ejection fraction of 30% and other global chronic dysfunction. The patient was extubated the night of admission and required only a nasal cannula throughout his stay. When sedation was held for neurologic reevaluation, he was noted to be able to follow all commands. His cardiac markers increased likely in the setting of cardiac arrest, hypotension, and CPR. PCI was completed the following day and showed no acute blockages. The 4 previously placed stents maintained adequate flow. An automatic implantable cardioverter defibrillator was placed, and the patient was monitored for a total of 8 days before discharge home. Two years later, the patient remains in good health with no complications from this event. He has had no neurologic sequelae from this event. His automatic implantable cardioverter defibrillator has not been activated to date. No specific cause of his cardiac arrest was determined.

Discussion

Cardiac arrest continues to be the most lethal public health event in the United States and abroad. Global incidence of cardiac arrest is estimated at 20 to 140 per 100,000 people annually, with greater than 500,000 events occurring in the United States.[1] Although survival rates to hospital discharge vary greatly and are dependent on a multitude of variables, they tend to hover at less than 15%.[1] What made this case interesting was the ultimate discharge of the patient at neurologic baseline despite prolonged down time, presumed persistent VF, and delayed defibrillation. The basic tenants of

cardiac arrest management will be reviewed, many of which led to a favorable outcome in this case.

The 2010 American Heart Association guidelines recommend increased attention to rapid, effective, and continuous chest compressions. Its importance is highlighted by the alteration of bystander CPR training to compression-only CPR. Although the reasoning is more complex, the trend clearly focuses on the importance of uninterrupted, high-quality compressions early in the management of cardiac arrest because the most effective compressions only provide about 10% to 30% of normal blood flow to the heart and 30% to 40% to the brain.[1]

Attention should be paid to oxygenation strategies during postarrest management. Older strategies of high-flow oxygen being beneficial to all patients have been disproven. In fact, hyperventilation and hyperoxygenation have been shown to lead to reduced cerebral blood flow because of vasoconstriction and the production of oxygen-derived free radicals during reperfusion.[2] Furthermore, secondary to acute lung injury, patients may develop regional ventilation/perfusion mismatch, leading to a decrease in arterial oxygenation. The severity of pulmonary dysfunction and lung injury is often measured by the PaO_2/F_IO_2 ratio. Maintaining a ratio less than or equal to 200, as part of a standard ventilation lung protection strategy, appears at this time to be the most prudent.[2]

Mechanical compression devices have been in existence since the 1960s when the first piston-type device was released. These have evolved to include adding a suction cup to assist in chest wall recoil and now are typically battery not gas driven as exemplified in the PhysioControl Lucas 2. Current evolutions include vest and load-distributing band devices such as the Zoll Autopulse that claim to promote greater forward blood flow by circumferentially squeezing the thorax. Unfortunately, the data to support the use of these devices are limited and lacking to date. Conflicting studies in 2006 showed variable results. The ASPIRE study was halted early because of worsening discharge outcomes,[3] whereas a study performed by the Richmond Ambulance Authority showed an increase of survival to discharge by 238% after out-of-hospital cardiac arrest.[4] The authors in the latter study believe that it was strategic, citywide placement and rapid application of the devices that accounted for their success because delays in device application and compressions are often cited as a major barrier to effective use. The 2014 update by the Cochrane Review Database concluded that there was insufficient evidence to support the widespread use of mechanical CPR devices.[5] Although the devices are intriguing for prehospital personnel in the logistical management of cardiac arrest, the price of each device (> $12,000) may delay widespread application until the data support the fiscal outlay.

Early access to defibrillation remains a crucial aspect of care, and speed continues to be paramount to a successful resuscitation of out-of-hospital cardiac arrest. VF is thought to be the most common dysrhythmia, with 74% of patients having a recurrence during management.[6] Interestingly, a 2010 article in *Circulation* suggests that delays in rhythm recognition as a result of 2 minutes of compressions immediately after shock might be detrimental to patient outcomes.[7] The authors suggest that recurrent VF often happens within the first few compressions after shock, and the delay in recognition may be harmful. Although the technology does not yet exist to monitor an electrocardiogram while performing compressions, the advent of mechanical compression devices certainly allows for a shock concurrent to thoracic compression.

Intravenous access continues to be a skill that although important need not consume vast amounts of time in the acute setting surrounding an out-of-hospital cardiac arrest. When venous access is delayed, given the situation or physiology, IO access remains the preferred method. Endotracheal absorption of traditional medications is variable and dependent on advanced airway placement, which has become a secondary treatment priority. Noteworthy with regard to IO access is that the humeral head is preferred because of the increased speed at which drugs reach central circulation.[8] In this case, the on-snow administration of epinephrine was performed through the proximal tibia.

Recent research is showing that higher than typical systolic blood pressure targets have a positive impact on patient survival. An article published this year showed that the use of intravenous epinephrine and fluids to maintain systolic blood pressures between 120 and 129 had the biggest impact on patient survival from "shockable" cardiac arrest.[9] This same study showed that as systolic blood pressures approached 90, there appeared to be a significant reduction in survivability from out-of-hospital cardiac arrest.

One persistent modality in the management of cardiac arrest that is not supported by research is the use of epinephrine. Although studies show improvements in return of spontaneous circulation after epinephrine use, none have actually demonstrated an increase in patient survival to discharge.[10] Increases in metabolic demand and myocardial oxygen consumption in the setting of sympathomimetic stimulation might actually be detrimental in the setting of cardiac arrest. With this new development in research, it is unclear how much longer epinephrine will remain in current standards of care.

Amiodarone has been shown to be an effective treatment for those patients experiencing persistent VF. A 2002 double-blind study published in the *New England Journal of Medicine* compared the effects of lidocaine and amiodarone and found that the latter leads to higher rates of survival to hospital admission.[11] Interestingly, Weaver et al[12] showed that any drug administration during cardiac arrest led to lower survival rates. They postulated that it was because of a delay in subsequent shocks. The optimal dosing regimen of 1,000 mg/d intravenously was established in a 1990 study that showed fewer recurrences of VF during treatment and subsequent care, especially in relation to oral antiarrhythmic use.[13] Interestingly, both the CASH and the CIDS studies showed that over time the most effective treatment for recurrent VF was an implantable cardioverter defibrillator.[14,15]