Outcomes following cardiac arrest in remote areas of the Northern Territory

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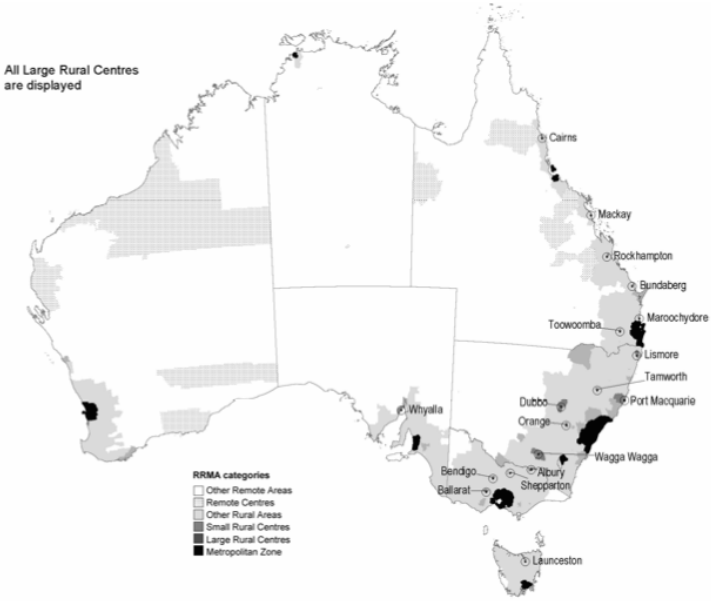
Introduction

Out of hospital cardiac arrest (OHCA) is a common cause of death worldwide, and there is a large amount of global research in this area. Survival from OHCA is extremely variable, but remains universally poor ranging from 0.6% to 31%, with a worldwide mean of 7% in a 2010 systematic review[1]. This review reports survival to discharge in Australia to be 11%, which is higher than those reported for Europe, North America and Asia (9%, 6% and 2% respectively).

Although several papers have looked at survival rates in areas of Australia[2-7], with some assessing outcomes in rural settings[8,9], to our knowledge none have assessed outcomes in the remote regions of Australia. In 2006 Jennings et al demonstrated a significant difference in mortality between urban and rural environments in Victoria, the latter having a significantly worse outcome (7.9% survival to discharge versus 1.9% respectively)[8]. More recently Nehme et al (2014) have demonstrated that population density is independently associated with survival in Victoria (15.2% in the very high population density versus 2.8% in the very low population density areas)[9]. The NT encompasses a vast area and, according to the 2011-2012 Australian Bureau of Statistics (ABS) figures, has an overall population density of 0.2 people/km^2. Using the definitions set by Nehme et al, this would make the NT population density 50 times lower than the threshold for a very low population density (very low populations density ≤10 people/km^2)[10]. Victoria on the whole has a very small area classified as remote as per the Remote, Rural and Metropolitan Area's (RRMA) classification, whereas the all areas of the NT outside of the Darwin region, with the exception of the Litchfield area, are classified as remote (figure 1)[11]. This combination of low population density and remote setting would suggest that patients suffering out of hospital cardiac arrests in the NT would have lower survival than those quoted in the literature. With the World Health Organization predicting the burden of ischaemic heart disease to increase over the coming years[12], cardiac arrest will certainly become an increasingly prevalent problem.

The primary response to emergencies and retrieval for transfer to a hospital in remote areas of the Top End of the NT is relatively unique in comparison to the predominantly road ambulance based systems reported in the literature. The initial emergency response is most commonly provided by remote health clinicians based in a local clinic, with further critical care treatment advice and subsequent retrieval provided by the Top End Medical Retrieval Service (CareFlight). Although advanced life support (ALS) is often administered in a timely manner by remote health clinicians based in the remote communities, the time for the patient to reach hospital can be several hours with the aim of CareFlight to bring critical care management to the patient in the remote community[13].

Figure 1 RRMA classification areas of Australia[11]



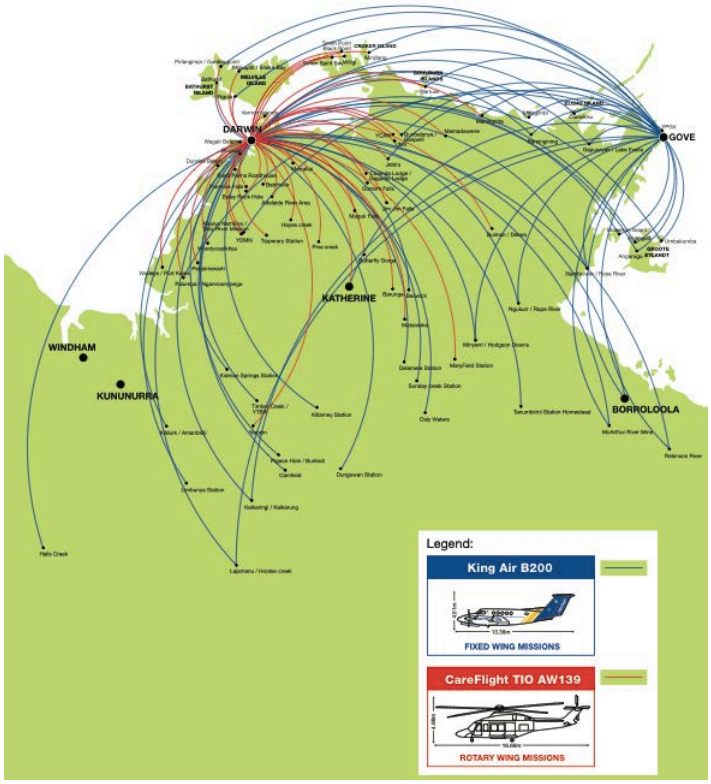
Our aim is to retrospectively identify all cardiac arrest referrals to our retrieval service and associated information including: response times; retrieval times; team composition; interventions performed; outcomes (survival at 1 day post arrest, 28 days and to hospital discharge). We hypothesise that the emergency response system that operates in remote areas of the Top End provides a level of care that allows for outcomes comparable to the rest of Australia and the world.

Methods

We conducted a retrospective study using the retrieval medical database and JADECARE hospital patient care records over a three-year period from January 2012 to December 2014. Cases were identified in the CareFlight medical database by searching for all cases with a diagnosis of cardiac arrest and/or intervention of CPR. In addition to this, we reviewed the medical record of all cases that were not transported due to patient death during this period to ascertain if they were appropriate to be included in the study. Of all identified cases, we reviewed the case notes in the retrieval medical database and the computerised hospital records. Those deemed not to have a cardiac aetiology for their arrest were excluded from the study.

The setting for the study was the area served by the Top End Medical Retrieval Service (CareFlight). This encompasses the area from the Melville Islands off the northern coast; Gove and Robinson River in the east; the state border in the west; and as far south as Elliot (figure 2). The city of Darwin and its surrounds are served by a road based ambulance service and as such these patients were not identified and included in this study.

Figure 2 Top End Medical Retrieval Service catchment area[14]



The data collected is based on the Utstein definitions and reporting template, which is used extensively in reporting outcomes following cardiac arrest[15]. These parameters were the initial rhythm, the duration of cardiopulmonary resuscitation (CPR), return of spontaneous circulation (ROSC), sustained ROSC, survival of event, survival at one-day post arrest, survival to hospital discharge and survival at 28 days. Sustained ROSC is defined as maintaining an output for greater than 20 minutes. Unfortunately documentation of timing of repeat arrests was poor. As such we have defined sustained ROSC as no further arrests during the transfer period. Survival of the event is defined as reaching hospital with an output. We also set out several other parameters to collect: Indigenous status; location of arrest; response times; retrieval times; retrieval team composition; interventions before and after the arrival of the retrieval team.

Full ethics approval from Menzies School of Health Research was granted for the study.

Results

A total number of 39 cases were identified for the 36-month period. Of these, 20 were deemed to not be a primary cardiac cause and were therefore excluded, leaving 19 cases for review. All causes of arrest are summarised in table 1. There was a 10:9 ratio of males to females, with a median age of 40 years (range 17 to 67). Seventeen of the 19 cases were Indigenous Australians (89.5%, 16 Aboriginal & one Torres Strait Islander), the remaining cases were one non-Indigenous and one case where ethnic background could not be identified from the records.

Table 1 Summary of cause of arrest in identified cases

Cause	Number	Percentage
All causes	39	100
Primary Cardiac	19	48.7
Primary Respiratory	4	10.3
Respiratory arrest only	2	5.1
Metabolic	2	5.1
Sepsis	2	5.1
Hanging	2	5.1
Electrocution	1	2.6
GI Bleed	1	2.6
Trauma	1	2.6
CVA	1	2.6
Ischaemic bowel	1	2.6
Unable to collect data	1	2.6
Cause unclear	1	2.6
Data entry error	1	2.6

The majority of cardiac arrests (73.7%) occurred prior to referral for retrieval. Thirteen (68.4%) were tasked as Priority 1 (P1) responses, five (26.3%) as Priority 2 (P2) responses and one (5.3%) as a Priority 3 (P3) response (P1, P2 & P3 responses have a target referral to departure time of 30 minutes, 2 hours and 6 hours respectively and are decided by the Medical Retrieval Consultant based on the patients current condition and local resources). The mean time in minutes from referral to teams departure, contact with patient and arrival at their final destination were 58.4 (range 12 to 156), 144.4 (range 63 to 266) and 322.5 (range 233 to 385) respectively. The team comprised of a flight nurse and a flight doctor on 17 (89.5%) occasions, and a flight nurse alone in two cases.

Eight cardiac arrests occurred in clinic, three at home, one in a district general hospital, six in public locations (shops, street etc) and one on an oil rig. Thirteen of the 19 cases (68.4%) received bystander CPR and the mean time before commencing CPR was 0.8 minutes (n=13, range 0 to 10 minutes). However for those occurring outside a hospital or clinic environment, bystander CPR occurred in four of 10 cases (40%). For two cases that occurred in public locations, it was unclear whether bystander CPR had been attempted. ALS (ie drugs, defibrillation) was started at a mean time of 3.2 minutes (n=13, range 0 to 22 minutes). The mean duration of CPR was 32.3 minutes (n=13, range 8 to 60 minutes).

Eleven cases were in a shockable rhythm (57.9%), with eight cases being in non-shockable rhythms. Of those in a shockable rhythm a mean of 2.6 shocks were delivered (n=9, range 1 to 10). A mean of 1.7 doses of adrenaline were administered (n=12, range 0 to 6), four cases had amiodarone administered and two had atropine. Three cases were thrombolysed, although it is not entirely clear when this took place (ie before, during or after the arrest). Five cases were intubated prior to arrival of the retrieval team, with a further two cases receiving a laryngeal mask airway (LMA, one of whom, was subsequently intubated). A further five cases were intubated and one having an LMA inserted by the retrieval team.

Table 2 Breakdown of presenting rhythms

Presenting rhythm	Number of cases	Percentage
VF	5	26.3
VT	1	5.3
Undefined shockable	5	26.3
PEA	2	10.5
Asystole	1	5.3
Undefined non-shockable	5	26.3

ROSC was achieved in 15 (78.9%) and sustained in seven (36.8%) cases. Ten (52.6%) patients survived the event. The median Glasgow Coma Score (GCS) on ROSC was 3 (n=10, range 3 to 15). Six cases were taken to the Emergency Department (ED) and four cases directly to Intensive Care Unit (ICU). Nine of the 10 event survivors had an ICU admission. All cases that survived the event remained alive the following day (n=10). Six cases survived to hospital discharge (n=18, 33.3%) and four were alive at 28 days (n=16, 25%). One case was transferred to another hospital, so discharge data was not available, and for three cases we were unable to ascertain whether they survived past 28 days. Making the worst-case scenario assumption that these patients did not survive to 28 days, 28-day survival would be 21%. The mean numbers of days in ICU and in hospital were 5.2 (range 0 to 15) and 14.3 (range 3 to 49) respectively.

Discussion

Patients in rural and remote areas of the Top End with whom aeromedical retrieval services are involved have a survival to hospital discharge rate of 33.3% and 28-day survival rate of at least 21%, which compares favorably to other published data. Although the number of cases in this study are extremely small, the authors feel the results are reassuring that current practices in the Top End of the NT are effective in providing a good chain of survival, particularly given the sparse population and long retrieval distances involved. To the author's knowledge, this is the first study assessing outcomes following cardiac arrest in remote regions of Australia.

One major contributing factor to the relatively high rate of survival could be the young age of patients, with 68% being aged 40 years or less. Given 89.5% of cases were Indigenous Australians, this statistic also reflects the extremely high burden of cardiovascular disease in the Indigenous populations of the NT. This trend is not new, and previous government research has shown that Indigenous males and females aged 35–54 years died from CHD at seven and 17 times the rates of non-Indigenous males and females respectively[16]. Furthermore, You et al showed the incidence of acute myocardial infarction (AMI) in the NT's Indigenous population from 1992 to 2004 to be 1.7 times greater than that of the non-Indigenous population[17].

The global incidence of ventricular fibrillation (VF) as a presenting rhythm is falling[1,3,18-21]. The reason behind this is not known, but some have hypothesised it to be related to improvements in the treatment of coronary heart disease[19] and reductions in age related mortality[20]. The rate of shockable rhythms in this study was 57.9%, and although many cases do not differentiate between VF and ventricular tachycardia (VT), VT comprises a very small proportion in other studies (0 to 0.5%)[2,3,4,8]. Assuming the vast majority to be VF, the rate is significantly higher than the worldwide and Australian mean from a 2010 systematic review by Berdowski et al (26.9% and 39.8% respectively)[1]. VF is thought to be caused by severe undiagnosed coronary heart disease[20], and the early onset and high burden of cardiovascular disease amongst the Indigenous populations would feasibly explain the high incidence in this data set. Numerous studies have previously described improved outcomes for those with an initial rhythm of VF and VT[1, 22], and as such the high incidence of shockable rhythms is likely a contributing factor to the high rate of survival seen in this study.

It is widely acknowledged that early interventions, namely prompt recognition, early CPR, rapid defibrillation and appropriate post resuscitation care, are key to the chain of survival and improve outcome in cardiac arrest[22-25]. Proximity of remote health clinics to remote communities and the fact many patients have a witnessed arrest within the clinic could certainly be a contributing factor to the

relatively high survival rate seen in these patients. For those who arrest out of the clinic only one in three received bystander CPR. It is the authors' impression from reviewing the case notes that in many of the other cases cardiac arrest was not identified until the arrival of clinic staff, so delays before commencing CPR may have been significant. As such, continued public education on the recognition of cardiac arrest and basic life support (BLS) could further improve outcomes.

A 2007 study conducted in Queensland by Woodall et al demonstrated that access to an intensive care paramedic was associated with a significant increase in survival to hospital discharge[7]. It was hypothesised by Nehme et al that the relatively low exposure to resuscitation practice amongst rural paramedics could contribute to the worse outcomes in rural populations[9], but evidence for this is sparse. Similar disparities in frequency of exposure to resuscitation practice could be apparent in remote health clinicians, and could adversely affect outcome. In contrast, there is research to suggest that provision of ALS over BLS in a pre-hospital environment does not improve outcome[26], and in an American study by Sanghavi et al published earlier this year, patients receiving ALS had a lower survival and poorer neurological outcomes[27]. There is also research suggesting minimally interrupted cardiac resuscitation improves outcomes[28,29], with the technique bearing a greater resemblance to BLS. This would suggest that focusing training on provision of good quality basic skills, namely CPR and bag-valve-mask ventilation, results in improved outcome. As such the authors advocate regular BLS training being undertaken by remote health clinicians.

The final link in the chain of survival is delivery of post resuscitation care, and is an area in which this study will differ greatly from others reported in the literature. As demonstrated the rural health practitioners are, on average, managing these cases for over two hours prior to the arrival of retrieval services, and the patients do not arrive in hospital for over 5 hours, where post resuscitation care would usually occur. The retrieval team composition of a nurse and doctor, both with an acute care background, means that post resuscitation care can be brought to the patient with interventions including endotracheal intubation, ventilation, invasive monitoring and intravenous infusions of sedation, inotropes, antiarrhythmics, antihypertensives and vasodilators all being available. A nurse/doctor team was dispatched in the majority (89.5%) of cases. In the two cases where a nurse only crew was activated, the patients had been stable at the time of tasking and suffered an unexpected deterioration. The provision of this level of care is likely to contribute to increased survival in this remote setting.

The Top End Medical Retrieval Service provided by CareFlight serves a large rural and remote area of the NT, but is not involved emergency response in urban areas. As previously mentioned the Darwin city area, and also the area around Katherine, the second largest town in the Top End, are served by a road ambulance service to their respective district hospitals. Many cardiac arrests in Katherine would subsequently be retrieved, but the decision to cease resuscitation may be made without this process being initiated, and as such cases in both these areas may not been identified and included in this data. In addition, this mix means that we were unable to accurately identify the population from which these figures were obtained, and as such the incidence of cardiac arrest could not be calculated.

The effect of living in a rural or remote environment on the incidence of cardiac arrest in Australia is sparse, and somewhat at odds with the prevalence of IHD and incidence of AMI. Jennings et al's and Nehme et al's studies showed lower incidence of cardiac arrest in rural areas and areas of lower population density respectively[8,9]. They did not however collect any data regarding ethnicity, and how this reflects on the incidence. Data compiled by the heart foundation from the Australian Bureau of Statistics (ABS), Australian health survey 2011/12 is conflicting suggesting the prevalence of cardiovascular disease is 26% greater in rural regions. However, these figures are also only reflective of non-Indigenous due to the low population and insufficient ABS data. In addition to this they are unable to comment on prevalence in the NT for the same reasons[30]. You et al's data from the NT showed the incidence of AMI to be two times greater in remote populations, but only in non-Indigenous people[17].

One limitation is that we have not captured patients who have not had a medical retrieval process initiated, so those who have been declared deceased at home or in the clinic before referral have been missed. It has been previously demonstrated that Indigenous people have a 1.4 times increased

rate of out-of-hospital death from cardiovascular disease[31] and 1.88 times the risk of pre-hospital death from AMI[17]. If all these events were captured the observed survival rate in our study would be lower.

Another limitation of this study is the small numbers involved. Retrospective data was limited prior to January 2012 due to changes in the clinical governance of the aeromedical retrieval services at this time. Expansion of this project to include the road ambulance service, aeromedical retrieval service providers from elsewhere in the NT, remote health services and registry of deaths, as well as extending the period over which data was collected would allow for much larger numbers to be elicited, and also allow for calculation of incidence using census population data. Other areas have introduced a statewide registry for cardiac arrests[4], and instigating something similar in the NT would be the most convenient way to collect data from all the services involved.

A larger sample size would also allow the data to be analysed in greater detail, using statistical methods to assess which factors contribute most to increased or decreased survival, and as such allow for a more focused allocation of funding and resources. For instance studies have shown that increased response interval and distance from hospital adversely affected outcome[4,8]. It would be of interest to see the effect of distance from Darwin, response and retrieval times on outcome.

Retrospective data collection and analysis has inherent limitations. Unfortunately the medical records available to the authors were moderately limited, making it difficult to accurately identify the main cause of the cardiac arrest in some cases. Those who were noted to have a presumed or possible primary cardiac cause were included in this study.

Conclusion

This study is limited due to the small numbers in the sample size, but suggests that the survival from OHCA in the Top End of the NT is at least comparable to other regions of Australia and the world. BLS training for non-health professionals and remote health clinicians may help to improve outcomes. In addition, further research in conjunction with other health service providers, potentially via the means of a statewide reporting system, could further the knowledge of the outcomes of patients who experience an out-of-hospital cardiac arrest in remote areas of the NT and inform where funding is best focused to improve outcomes further.

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Presenter

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