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Practices and outcomes of resuscitation in cardiac arrest at a South African Emergency Department

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Practices and outcomes of resuscitation in cardiac arrest at a South African Emergency Department

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Manuscript for submission

Type of article

Original Research

Title of Manuscript

Practices and outcomes of resuscitation in cardiac arrest at a South African Emergency Department

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Author 1 (student) CM: Responsible for the study design, data collection and analysis, and write-up

Author 2 (main supervisor) CL: Contributed towards review, revision and approval of manuscript

Author 3 (co-supervisor) PS: Contributed towards review, revision and approval of manuscript

Abbreviations

AAM	Advanced airway management
AHA	American Heart Association
BVM	Bag-valve-mask ventilation
CPR	Cardiopulmonary resuscitation
CVD	Cardiovascular disease
ED	Emergency Department
ETI	Endotracheal intubation
HIV	Human immunodeficiency virus
HJH	Helen Joseph Hospital
IHCA	In-hospital cardiac arrest
ILCOR	International Liaison Committee on Resuscitation
OHCA	Out-of-hospital cardiac arrest
PEA	Pulseless electrical activity
PPE	Personal protective equipment
RCT	Randomised Control Trial
ROSC	Return of spontaneous circulation
SGD	Supraglottic device
SSH	sub-Saharan Africa
USA	United States of America

Practices and Outcomes of Resuscitation in Cardiac Arrest at a South African Emergency Department

ABSTRACT

Objectives:

This study aimed to investigate the patient and resuscitation factors affecting outcome after cardiac arrest in the low-middle income setting.

Methods:

We retrospectively reviewed the data of patient's aged ≥18 who experienced in-hospital cardiac arrest in the Emergency Department between January 2020 and December 2020 at a tertiary hospital. The data collection period included the first wave of the COVID-19 pandemic in South Africa. Return of spontaneous circulation (ROSC) was the outcome of interest. The registry from which data was collected was audited.

Results:

98 patients were included. The ROSC rate was 43%. Asystole was associated with poor outcomes (likelihood 7.73, $p \leq 0.01$). Cardiac standstill on ultrasound was associated with poor outcome (likelihood ratio 6.559, $p \leq 0.01$). There was a significant improvement in ROSC after the first wave of the COVID-19 pandemic and a transition from airway management with bag-valve-mask to endotracheal intubation intra-arrest ($p=0.04$). Demographic factors, defibrillation and drug-use were found to have no significant impact.

Conclusions:

The resuscitation practices and outcomes in the low-middle income setting are similar to high-income settings. Further research on the impact of the COVID-19 pandemic on resuscitation outcomes in this setting is necessary.

Keywords:

In-hospital cardiac arrest; Cardiopulmonary resuscitation; COVID-19; Registry audit

INTRODUCTION

Cardiac arrest is a common presentation in the Emergency Department (ED). It refers to the cessation of cardiac activity, and thus tissue perfusion, with resultant functional impairment and ultimately death if left without intervention. Resuscitative efforts aim to achieve return of spontaneous circulation (ROSC) and survival-to-discharge with intact neurological functioning. Definitions of survival vary between studies and include transfer to ICU, inter-hospital transfer or discharge home. This diversity makes comparison of survival challenging. To compound this issue, most studies are conducted in high-income, developed countries. In the United States of America (USA), survival-to-discharge from in-hospital cardiac arrest (IHCA) was 25%. (1) The survival rate in most developing countries, such as South Africa (SA), is unknown.

The success of resuscitative efforts is determined by factors pertaining to the patient, the provider, and the components of resuscitation. High-quality chest compressions, early defibrillation and the identification and treatment of reversible causes remain the cornerstones of effective cardiopulmonary resuscitation (CPR) as recommended by the American Heart Association (AHA). (2) The association of other interventions, such as advanced airway management (AAM) techniques, with patient survival is uncertain and the optimal approach remains to be identified. (3) Ultrasound-use in resuscitation has increasingly become part of routine resuscitation practices. In the hands of the trained provider, ultrasound-use has been shown to aid in accurate identification of reversible causes of pulseless electrical activity (PEA) arrest with resultant increased chances of survival. (4)

In 2020, the SARS CoV-2 virus changed practices worldwide. In response to the COVID-19 pandemic, the AHA amended their CPR recommendations to include practices aimed at mitigating the risk of transmission to providers. These recommendations included a reduced number of providers involved in resuscitative care, wearing of personal protective equipment (PPE) before attending to patients needing resuscitation and prioritizing early AAM. (5) The impact of these changes has yet to be examined in a resource limited setting.

Although there is a large body of literature on resuscitative medicine, there are still gaps in our knowledge base. (6) Limited literature on resuscitation outcomes and practices in low-income settings has been identified. Further research could identify factors that influence CPR outcomes which, when targeted, could improve patient survival. This study aims to evaluate

resuscitation practices and outcomes at a public ED in Johannesburg, South Africa as well as to investigate the impact of the COVID-19 pandemic on resuscitation.

METHODOLOGY

Ethics approval was granted by the University of the Witwatersrand Human Research Ethics Committee (Medical), (Clearance Certificate no. M210219)

Study settings and population

This study was the first single-center retrospective descriptive study of patients aged ≥ 18 years who had IHCA in the ED of Helen Joseph Hospital (HJH) from January 2020 to December 2020. HJH is a tertiary level public hospital located in Johannesburg, SA that services a low-to-middle income population. HJH ED makes use of AHA guidelines as the basis of its resuscitation practices and use of manual defibrillators is standard practice. Access to cardiac catheterisation is via transfer to the nearest quaternary hospital which is less than 6km away

Only patients who arrived in cardiac arrest or developed cardiac arrest while in the ED were included . Cardiac arrests in children aged < 18 years were excluded.

The primary outcome was ROSC.

Data collection

The CPR registry and patient records at HJH ED were retrospectively reviewed. Eligible registry entries were assigned an identification number. At the time of review, data contained in the registry were largely in accordance with the Utstein-Style Recommended guidelines for standardized reporting of cardiac arrest but did not include pre-cardiac arrest Cerebral Performance Category (CPC) scores, supplemental pre-event data or post-resuscitation process data.

In addition, the registry was audited to assess data quality. Forty-three entries were selected using a random number generator. An entry was considered incomplete if data fields had been left blank. To assess data accuracy, entries were compared with patient records. Where the records were incomplete or the patient file could not be located, a new entry was randomly selected for audit until a complete patient record was obtained. Data was considered inaccurate if it differed from the patient record. This was the first audit of the registry.

Convenience sampling was used to achieve a target samples size of 90 (effect size 0.6, significance level 0.05, power 0.8) for the registry review. Survey sample methodology was used to calculate the sample size of 43 for the audit. A confidence level of 95 (expected proportion of 0.95) and a confidence interval of 0.05 were used.

Variables

The data extracted for analysis were classified into core-patient and core-process factors. Core-patient factors included: age; sex; comorbidities; and presumed cause of arrest (working diagnosis). Core-process factors included: initial cardiac rhythm at arrest; outcome of resuscitation (ROSC, 72-hour survival, rearrest); CPR duration; drugs used; ultrasound-use and findings; and airway control method.

Statistics

Data were collected and prepared prior to analysis. Missing data and outliers were accepted to preserve sample size and study power. SPSS (IBM, Armonk NY) software was used for data analysis. All variables were compared with resuscitation outcomes. Chi-squared tests were conducted to assess for significant associations. A P-value < 0.05 was considered statistically significant, with a 95% confidence interval.

Privacy

Clinical and identifying information were separated. An identification number was assigned to each data entry by the primary author. Data entries were kept in a secure, password encrypted data spread sheet only accessible to the primary author. Registry entries were only accessible to the primary author and the gatekeeper of the HJH ED CPR registry.

RESULTS

Patient characteristics

During the study period, one hundred cardiac arrests were entered into the registry. Two registry entries were excluded from analysis as they included cardiac arrests in patients aged <18 years leaving ninety-eight registry entries available for analysis.

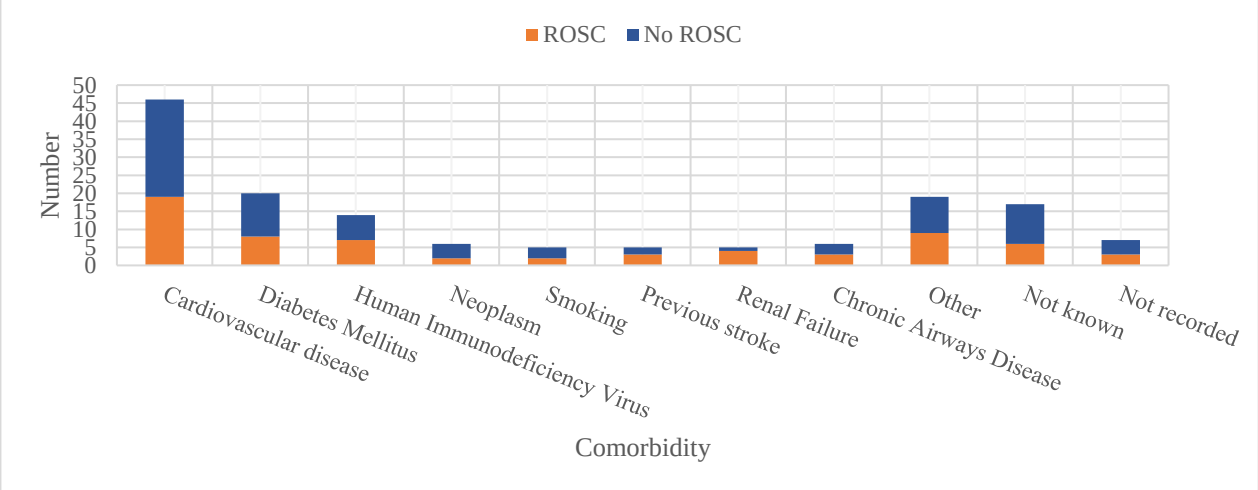
The median age (IQR) at cardiac arrest was 51 (33) years of age [CI 46.7-55.3 (std dev 19.9)] and 36% (n=35) of the study population were male (Table 1). Sex data for 25% (n=25) were missing.

Table 1 Characteristics of patients presenting in cardiac arrest (N=95*)

Variables	ROSC, n = 42	No ROSC, n = 53	P-value
Age, median (IQR)	55 (31)	52 (33)	0.11
Sex			
Male, n (%)	16 (38.1)	17 (32.1)	0.27
Female, n (%)	17 (40.5)	20 (37.7)	0.39
Missing, n (%)	9 (21.4)	16 (30.2)	0.16
Illness Category			
Medical, n (%)	31 (73.8)	46 (86.8)	0.05
Surgical, n (%)	7 (16.7)	0	0.001
Trauma, n (%)	3 (7.1)	5 (9.4)	0.34
Missing, n (%)	0	2 (3.8)	0.10
Primary Diagnosis			
Cardiac, n (%)	7 (16.7)	7 (13.2)	0.32
Respiratory, n (%)	12 (28.6)	7 (13.2)	0.03
Others, n (%)	23 (57.1)	39 (73.6)	0.03

** Outcomes (i.e., ROSC or no ROSC) for 3 patients were not recorded in the CPR Registry*

Fig 1: Baseline comorbidities of patients presenting in cardiac arrest (N=98)



Of the ninety-eight cases of cardiac arrest, 81% were due to medical illness. The most common pre-existing illness was cardiovascular disease (48%) (Figure 1) and 14% of patients were human immunodeficiency virus (HIV) positive.

Resuscitation process

The median CPR-duration was 11 minutes (IQR 19, mean 9.8 minutes). PEA was the most common initial cardiac rhythm identified. Defibrillation was undertaken in 22% (n=22).

Adrenaline was the most utilized drug during resuscitation. It is noted that for 18% (n=18) of patients, adrenaline was not used. Table 2 shows them characteristics of the arrests in which adrenaline was not used. Amiodarone was used as the antiarrhythmic agent of choice in 9% (n=9) of cases. Lidocaine was not used in any of the data entries. Other drugs were given to treat potentially reversible causes of arrest.

Table 2: Characteristics of arrests where adrenaline was omitted

Variable	Total
Illness Category	
Medical	16
Non-Medical	2
Initial Rhythm	
Shockable	13
Non-shockable	5
Outcome	
ROSC	5
Non-ROSC	13

Point of care ultrasound was used in the majority (61%, n=60) of cases to complement CPR activities with a potentially reversible cause of arrest identified in 12% (7 of 60 cases) (Fig 2).

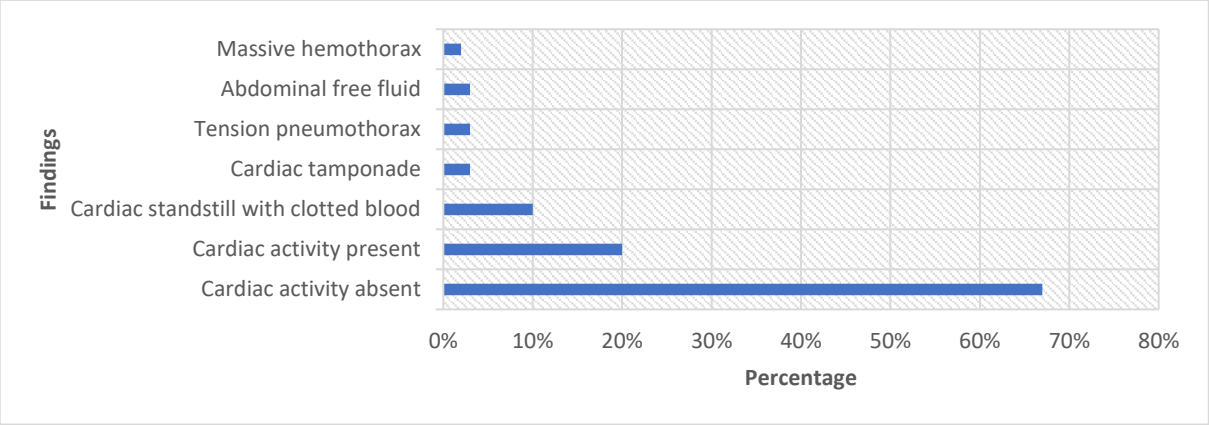


Fig. 2 Ultrasound findings in cardiac arrest in the Emergency Department at Helen Joseph Hospital (n=60*)

**Overlap between findings occurred*

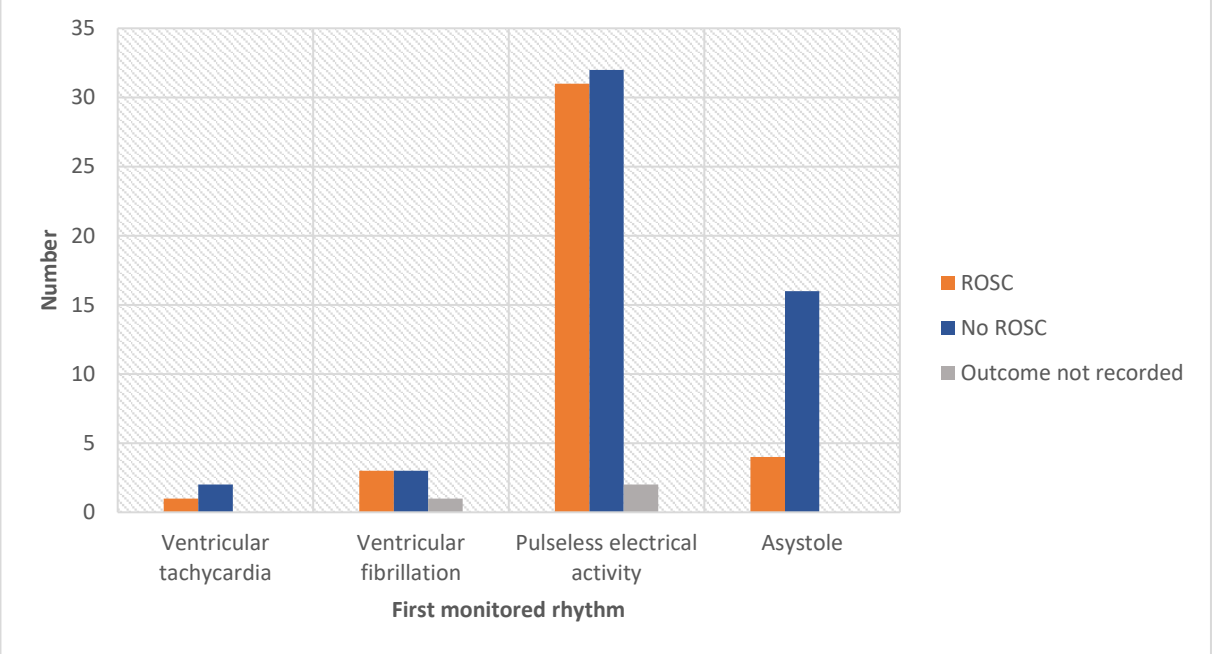
Comparison of the ROSC and no-ROSC groups

The overall ROSC rate was 43% (n = 42) . Data on the 72-hour survival rate was available for the 43 audited registry entries only and was noted to be 9.3% (n = 4 cases out of 43 audited registry entries). No data on neurological outcomes was available.

Age and sex had no significant impact on outcome (p = 1.00, p = 0.62). No statistical difference was observed between the ROSC and no-ROSC groups when baseline patient comorbidities were compared.

When asystole was the initial monitored cardiac rhythm, the ROSC rate was lowest (20%, 4 of 20 cases). This was statistically significant (p = 0.007, [CI 0.04, 0.37]) (Fig. 3). Irrespective of the initial rhythm, there was no statistical difference in outcome whether or not defibrillation was undertaken (p=0.46, p=0.44).

Fig. 3 First monitored rhythm in cardiac arrest in the Emergency Department at Helen Joseph Hospital



There was no statistically significant evidence that drugs used in resuscitation had an influence on outcome.

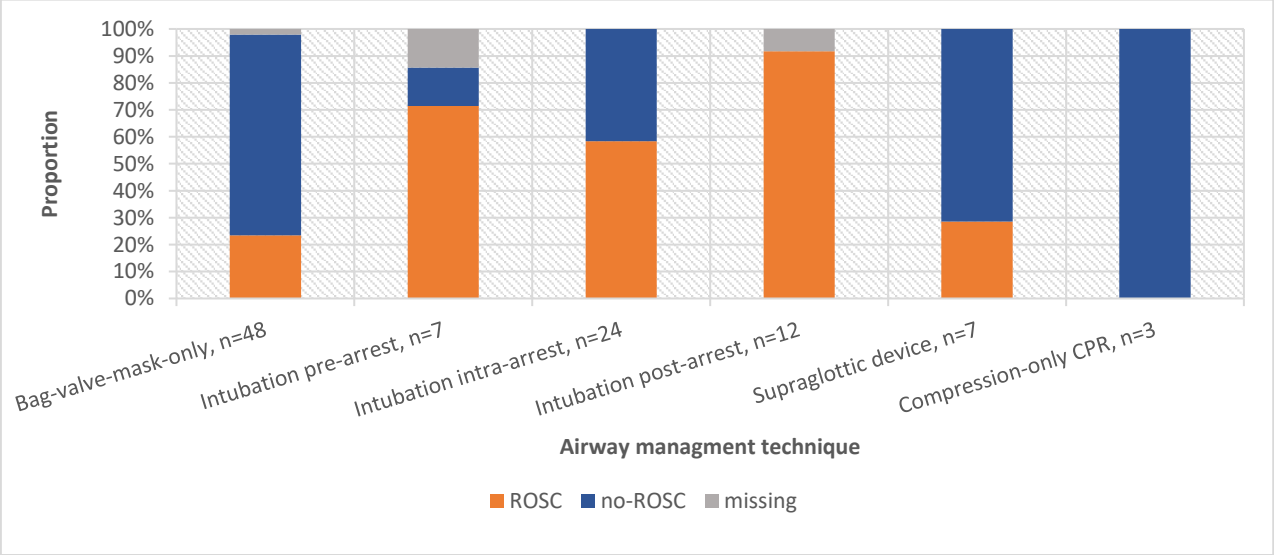
Ultrasound-use during resuscitation was not associated with significant impact on outcome. However, the presence of certain ultrasound findings was significantly associated with outcome. Patients with cardiac standstill on ultrasound had a lower ROSC rate than those who did not (23.1% vs 57.9%, p = 0.00, [CI 0.15,0.55]).

Comparison of airway management techniques with outcome

It is evident that there is overlap between different methods of airway control with Bag-valve-mask (BVM) ventilation , on occasion, preceding a definitive airway strategy either intra- or post-resuscitation. The frequency with which this multimodal strategy occurred is unclear from the registry entries.

Figure 4 demonstrates the relationship between airway management technique and outcome. There was a statistically significant difference in outcome in patients who were intubated post-arrest versus those that received any other type of airway management (Chi square p=0.00, likelihood ratio 20.047 [p=0.0003]). Those that received airway management with BVM-only during CPR were less likely to survive (ROSC rate 23% vs 62%, likelihood ratio 18.16, p=0.0002).

Fig. 4 Airway management techniques, shown by outcome



Comparison of resuscitation before and after COVID-19 pandemic

The study period encompassed the initial two waves of the COVID-19 pandemic in SA. However, as SA officially entered the second wave on 15-Nov-2020, which ended on 9-Jan-2021 according to the National Institute for Communicable Diseases (NICD) (7), data pertaining to the second wave is limited as it outdates the data collection period and hence has been excluded from Table 3. The characteristics and outcomes of resuscitation at the study

hospital during the initial wave of the COVID-19 pandemic in South Africa are shown in Table 3. Resuscitation was performed on a total of six proven COVID-19 positive patients. Of note, no COVID-19 PCR testing was conducted in 36 of the 98 patients (36.7%).

Table 3: Comparison of resuscitation characteristics and outcomes at Helen Joseph Hospital emergency department in the period before, during and after the first wave of the COVID-19 pandemic in South Africa (n=79)***

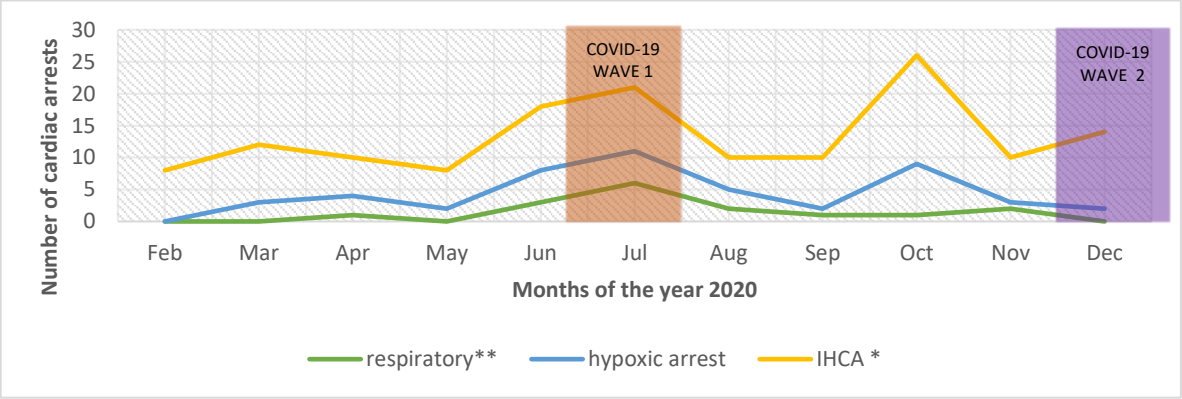
	Pre-COVID-19 n=29	COVID-19 wave 1* n=20	p value	Post-COVID-19 wave 1 n= 30	p value
Outcome					
ROSC, n (%)	11 (38)	7 (35)	0.41	18 (60)	0.04
No ROSC, n (%)	16 (55)	13 (65)	0.09	12 (44)	0.04
CPR duration, mean ± SD	8.8 ± 7.4	12.3 ± 12.5	0.14	8.6 ± 9.7	0.14
First monitored rhythm					
Pulseless electrical activity, n (%)	19 (65)	11 (55)	0.24	20 (68)	0.17
Asystole, n (%)	4 (14)	7 (35)	0.05	6 (20)	0.12
Ventricular fibrillation, n (%)	3 (10)	2 (10)	0.50	2 (8)	0.40
Ventricular tachycardia, n (%)	2 (7)	0	0.11	0	-
Airway control type					
Intubated pre-arrest, n (%)	0	2 (10)	0.04	3 (8)	0.4
Intubated intra-arrest, n (%)	7 (24)	2 (10)	0.10	9 (32)	0.04
Intubated post-arrest, n (%)	3 (10)	1 (5)	0.25	6 (16)	0.11
SGD** intra-arrest, n (%)	0	1 (5)	0.11	3 (12)	0.20
SGD** post-arrest, n (%)	0	1 (5)	0.11	1 (4)	0.43
Bag-valve-mask, n (%)	20 (69)	13 (65)	0.38	7 (24)	0.02
Ultrasound-use, n (%)	19 (65)	16 (80)	0.13	13 (48)	0.01

*COVID-19 wave 1: week 24-28 of 2020 (7/6 – 11/7)
** SGD denotes Supraglottic Device
***Data for COVID-19 wave 2 (n=19) has been excluded as the study period did not cover the whole second wave

Pre-arrest intubation increased from 0% pre-first wave to 10% during the first wave (p = 0.04, [CI 0.09, 9.99). Intra-arrest intubations increased significantly from the first wave to the period after the first wave (p = 0.04, [CI -0.02,0.46]). Ultrasound-use was highest during the first COVID-19 wave.

The rate of ROSC increased significantly from 35% during the first wave to 60% after the first wave (p = 0.04, [CI -0.03, 0.53]). Although not statistically significant the incidence of arrests thought to be secondary to hypoxia increased from 27% pre-first wave to 50% during the first wave (p = 0.05). Figure 5 illustrates the frequency of arrest due to hypoxia over the study period. PEA remained the most common initial rhythm.

Fig. 5 A comparison of frequency of arrests due to respiratory disease and overall incidence of cardiac arrest in ED over time



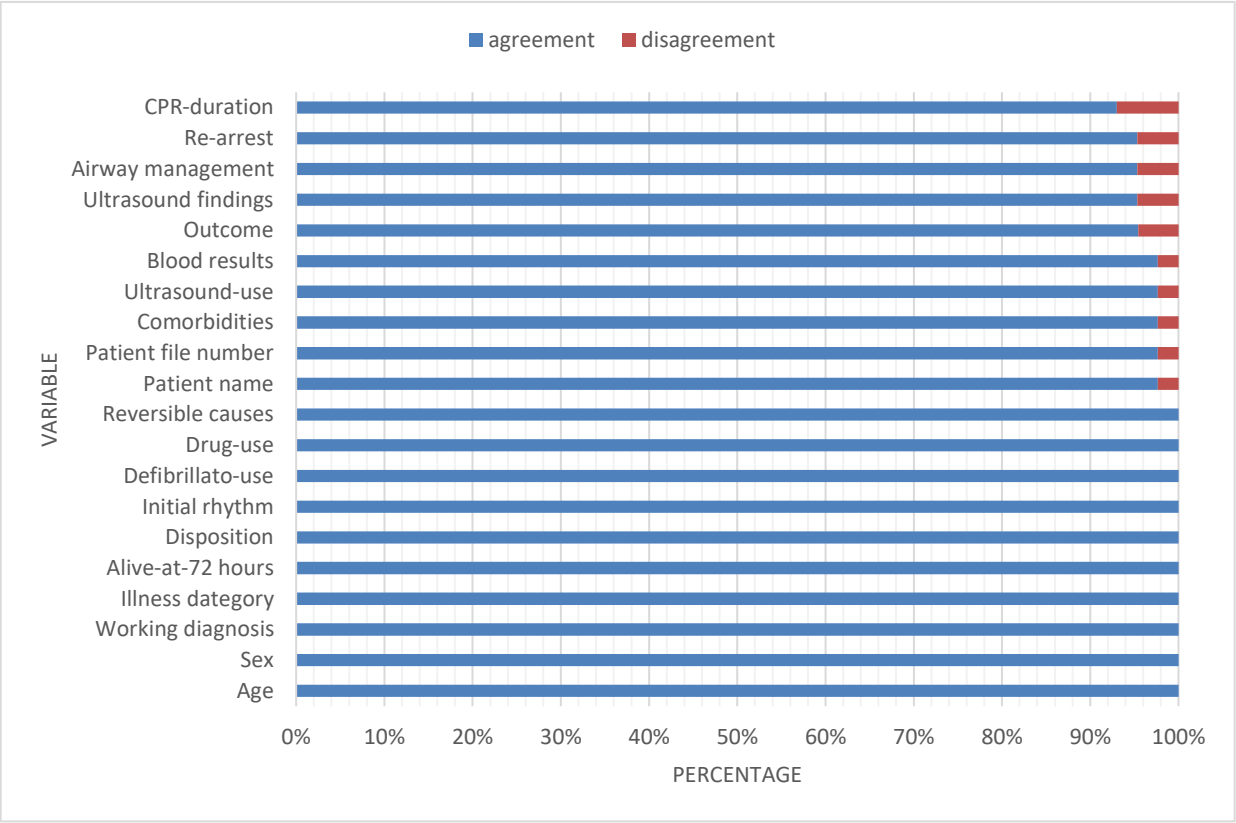
*IHCA denotes in-hospital cardiac arrests in the emergency department
**Respiratory denotes cardiac arrest with underlying respiratory cause

Audit of CPR registry

A total of 860 data points were assessed, representing 20 variables per record for 43 records. The overall data completeness was 96%. The variables with the lowest data completeness level were alive-at-72 hours and disposition – 88% (38/43 each). Re-arrest and comorbidities had the second lowest completeness level – 93% (40/43).

The overall data agreement (Fig. 6) was 98% (844/860). A median agreement of 99% was found when stratified by variable. Perfect data agreement was achieved in 50% (10/20) of variables. The variable with the lowest data agreement was CPR-duration 93% (40/43). Discrepancies were found in 23% (10/43) of the records. Information discrepancies were the most common cause of disagreement. Transcription, missing, and time discrepancies were found in one record each.

Fig. 6 Overall data agreement of data registry entries



DISCUSSION

This study aimed to describe the characteristics and outcomes of IHCAs in the emergency department of a resource-limited setting.

Patient Characteristics

The mean age at cardiac arrest in this study occurred at age 51. Though data on IHCA in Africa is limited, in Kenya the mean age of cardiac arrest was 59. (8) This is earlier than in the USA where the mean age at cardiac arrest is 66 years of age. This difference mirrors the incidence of CVD in Sub-Saharan Africa (SSA) which is on average two decades earlier than in high-income countries. (10)

CVD is the most common cause of arrest after communicable diseases in sub-Saharan Africa (SSA) accounting for 35% of all deaths. (10) CVD was the most common pre-existing condition in this study population followed by diabetes and Human Immunodeficiency Virus

(HIV). SSA carries 70% of the global burden of HIV which is associated with both increased risk and earlier onset of CVD. (10, 11)

Cardiac arrest process

Airway management involved BVM ventilation in the majority of cases. Approximately one-quarter of patients in this study were intubated intra-arrest. In comparison, SGDs were used in very few cases in this study and was similarly low in another South African study. (12) The comparative low rate of SGD to ETI use may be due to low level of availability in state hospital EDs and/or provider preference and relative increased experience with ETI usage. Further studies to examine the barriers (if any) to use of SGDs and attitudes amongst providers may be useful to confirm these hypotheses.

Advanced airway strategies may be deemed necessary after an assessment of the clinical scenario (including patient and provider characteristics). (2) A retrospective analysis of IHCA in USA hospitals found that early intubation was not associated with improved outcomes. (3) However, this association was found to be limited to patients without respiratory failure (15). In our study, ETI was used three times less than in other SA studies (12), despite a relatively high prevalence of respiratory disease amongst our study population. The benefits of ETI include a significant reduction in no flow ratio and an improvement in ventilation without impairing CPR quality. (16) Though not statistically significant, ETI was associated with higher rates of ROSC in arrests due to hypoxia, suggesting that arrests due to primary respiratory etiology are better managed with advanced airway techniques.

In accordance with current AHA guidelines, adrenaline was used in most cardiac arrests in this study. It is interesting to note that it was omitted in 18% of patients. Possible reasons may include early return of ROSC (i.e., before adrenaline administration was achieved) or initial shockable rhythms with successful defibrillation attempts. It is also possible that data was captured incorrectly (omitting to document the use of adrenaline). An alternative hypothesis is that adrenaline was omitted in error although its use was indicated. If this is found to be so, additional support and education may be required as in-service training to ensure that all members of staff are familiar with resuscitation protocols.

More recently, the influence of adrenaline on resuscitation outcomes has been studied. Despite improved ROSC and 30-day survival with adrenaline use, a large, randomised control trial (RCT) comparing adrenaline to placebo in OHCA showed worsened neurological outcome

with adrenaline use. (17) In contrast, a recent ILCOR systematic review which included the afore mentioned study, found no significant difference in neurological outcome at 3 months. (18) No significant difference in outcome was demonstrated when adrenaline was used in this study.

Certain ultrasound findings were significantly associated with outcome. When cardiac activity was identified on ultrasound, ROSC occurred more frequently. In keeping with literature, cardiac standstill, and visualization of a clot on cardiac ultrasound was associated with poor outcome. (1) The AHA recommends that ultrasound may be used as an adjunct to CPR when an experienced sonographer is available, provided it does not interfere with the performance of routine resuscitation practices. (2) Although there is limited evidence that ultrasound-use impacts patient outcomes, it has been shown to correctly identify cardiac activity in PEA arrest as well as reversible causes of arrest such as cardiac tamponade. (2,19) Though more research is necessary, ultrasound continues to be incorporated into cardiac arrest management.

Resuscitation Outcomes

The ROSC rate in this study (43%) was comparable to the overall global in-hospital average. (1) In Kenya, 35% of IHCAs achieved ROSC. (8) In another South African study, the ROSC rate was higher at 49%. (9) Differences in outcomes may be due to multiple patient and institutional factors. A true comparison of outcomes amongst studies is difficult due to varying baseline patient characteristics, institutional practices, and varying definitions of survival. In addition, there is a paucity of African studies addressing IHCA and lack of standardized reporting due to the absence of registries compliant with Utstein principles. Long-term outcome measurements (such as alive-at-72 hours, survival-to-discharge, neurological outcome) are challenging in the ED setting where follow-up is difficult due to rapid turnover, lack of robust record keeping and absence of an overall cardiac arrest resuscitation reporting system.

Influence of COVID-19 pandemic

No significant effect of the COVID-19 pandemic on outcome was demonstrated in this study. However, an impact on resuscitation practices in the period before and after the first wave of the COVID-19 pandemic in South Africa was noted.

Although PEA remained the most common initial cardiac rhythm before, during and after COVID-19 waves in this study, the proportion of hypoxic arrest almost doubled during the first COVID-19 wave. In New York, a transition in cause of arrest from cardiac (from 34.5% to

9.1%) to respiratory (from 21.8% to 49.1%) during the pandemic was found. (20) Similar findings were shown in Wuhan, China with studies showing that 87.5% of patients in cardiac arrest during the first COVID-19 wave had a respiratory cause as the underlying trigger for their cardiac arrest. (21)

We noted a statistically significant difference with an increased number of patients receiving pre-arrest intubation when we compared data pre-COVID-19 to both during and after the first wave in South Africa. This may reflect the increased incidence of a respiratory cause of cardiac arrest in the COVID-19 first wave with an increased burden of respiratory illness overall within the ED. This may account for the finding that intra-arrest intubations decreased during the first wave. Interim guidance from the AHA and ILCOR recommend that early intubation should be done by the most experienced provider during CPR in the setting of COVID-19. (22) Our study suggests that critically ill patients were intubated and ventilated within the ED during the COVID-19 pandemic prior to their arrests as was anecdotally our experience. This management likely reflects an access block to critical care services in our low- middle-income setting.

Ultrasound-use peaked during the first COVID-19 wave in our study. This may be because of early usage of ultrasound to look for reversible causes and to guide resuscitation efforts. Further literature establishing the accuracy of ultrasound in this role and the impact of revised resuscitation practices during the COVID-19 pandemic is recommended.

Audit conclusions/findings

A high level of data completeness and agreement were found. Time-based variables – namely alive-at-72 hours and disposition – had the lowest data completeness. This likely reflects the difficulty of patient follow-up in the ED due to rapid turnover of patients, shift work (which means that staff do not see patients to the completion of their care) and poor record keeping.

CPR-duration had the lowest data agreement at 93%. Despite recommendation from ILCOR, allocation of resuscitation team roles including timekeeper can prove difficult in the resource limited-setting where teams often include less than the six members proposed by the AHA. In addition, time keeping may prove challenging as CPR is often initiated before timing begins. This could be mitigated by the installation of an easily accessible timer installed at each resuscitation bay.

Information discrepancies, defined as differences in the data recorded between the registry and patient files, were the most common data disagreements identified. Disagreement in airway

management and ultrasound findings may be due to ambiguity in registry design/response options such as inadequate definitions or interpretations. Based on this we recommend that personnel who are to complete registry entries receive training and that aspects of the registry be reviewed. With regards to the latter, we suggest that data definitions be reviewed and made more specific, and that their definitions be incorporated into the registry forms.

LIMITATIONS

Our study findings should be interpreted in the context of several limitations. Given that our sample size is small, this may have limited the identification of significant associations. The quality of evidence in our study was limited by incomplete registry entries and missing patient records. The retrospective univariate nature of the study (conducted in only one hospital) limits its external validity.

CONCLUSIONS

The ROSC-rate in our study population was similar to both international and local findings. Comparison of long-term resuscitation outcomes is difficult due to lack of standardized definitions and data systems in South Africa. In keeping with available literature, age at cardiac arrest is on average a decade earlier in our study than in high-income countries with CVD a leading cause of cardiac arrest. The increasing prevalence of CVD is multifactorial and concerning, deserving of more public health attention. Differences in resuscitation practices from international norms may be attributed to limited resources and may indicate a need for more in-service staff training. More research on IHCA in South Africa and the impact of the COVID-19 pandemic would be beneficial.

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Appendix A: CPR Registry

CPR Registry

Date: _____ CPR Duration_____

Patient Name:	_____ Age:___	File no:_____
Male/Female	Comorbidities: _____	
Working Diagnosis:	_____	
Illness category:	Medical / Surgical / Trauma	
Outcome:	ROSC / Demised / DOA	Alive at 72 hours: Y/N
Disposition:	General ward / HCU / ICU / Not Applicable	

Initial rhythm

☐PEA ☐V fib
☐asystole ☐V Tach

Defibrillator used? ☐Yes ☐No # shocks delivered _____

Ultrasound used? ☐Yes ☐No

Ultrasound Findings

☐Tension Pneumothorax
☐Cardiac Tamponade
☐Abdominal Free Fluid

Cardiac Activity:
None / Some / Clot in heart

Airway Management

☐intubated intra arrest ☐intubated post arrest ☐supraglottic device intra arrest ☐supraglottic device post arrest ☐BVM

Drugs used

☐adrenaline ☐lidocaine ☐other (please specify)
☐amioderone ☐none _____

Reversible cause present

☐hypoxia ☐hypothermia ☐MI
☐hyperkalemia ☐hypoglycaemia ☐Tamponade
☐hypokalaemia ☐acidosis ☐Tension pneumothorax
☐hypovolemia ☐PE

Blood results

pH _____ pCO2 _____ BE ____ K _____ glucose

Barcode

Did this patient arrest again? ☐No ☐Yes #times: __
☐

Medical/surgical reg involved _____

*Short code:*_____

Appendix B: Research Proposal

Practices and Outcomes of Resuscitation in Cardiac Arrest at a South African Emergency Department

Dr Cathryn Sarah Martin
Student Number: 1819964
Degree: MMed Emergency Medicine

Supervisors:
Dr Carolyn Lewis, MBChB(UCT), FCEM(SA), MMED(UKZN), DipROM(RCSEd), DipPEC(SA)

Dr Patricia Saffy, MBBCh(WITS), FCEM(SA), MSc(Med) in EM, DipPEC(SA), DA(SA)

BACKGROUND

Cardiac arrest refers to the cessation of cardiac activity and thus tissue perfusion that results in functional impairment and ultimately death if left without intervention. Cardiopulmonary Resuscitation (CPR) is an intervention which primarily entails the use of chest compressions and rescue breathing on the patient who presents pulseless and without normal breathing. The aim of CPR together with other resuscitative interventions, is to achieve return of spontaneous circulation (ROSC). To assist the provider with the aim of achieving ROSC, The International Liaison Committee on Resuscitation (ILCOR) reviews the latest scientific evidence and formulates recommendations for resuscitation practices which are then adapted into guidelines by various bodies around the world. This includes the American Heart Association (AHA) whose guidelines are widely used in South Africa.

The rate of ROSC is variable. In Out-of-Hospital cardiac arrests (OHCA), ROSC occurs in 25-30% of cases[1]. This contrasts with 40-50% in In-Hospital cardiac arrest (IHCA)[1]. However, this is not the only measure of successful resuscitation. It could be considered that return to normal baseline neurological functioning and sustained survival days after CPR together with other resuscitative interventions are

the true measures of successful resuscitation. The average rate of survival to hospital discharge for in-hospital cardiac arrest is 17 to 20% [2] after achieving ROSC. Of those who survive, where they had normal cerebral performance pre-arrest, 86% maintain this level of performance [2]. Furthermore, the success of resuscitation is influenced by several factors. These factors may be categorized into those pertaining to the patient, the provider, and the process of CPR and associated interventions.

CPR-related factors associated with increased survival include the duration of CPR, early defibrillator use, method of airway control and quality of chest compressions performed. The ideal method of performing these interventions is outlined in resuscitation guidelines which are regularly revised. However, the optimal duration of resuscitation efforts has yet to be clearly defined – with studies showing contradictory findings. The duration of resuscitation attempts has been shown to be an independent predictor of mortality both during and after arrest [3] with longer resuscitation attempts (more than 15 minutes) being linked to decreased rates of ROSC and survival to discharge. In contrast, hospitals that carried out longer resuscitation attempts overall were found to have higher survival rates than those in which resuscitation attempts were shorter[4]. Though the reason for this is not exactly known, it is postulated that this difference may be attributable to inter-hospital differences in clinical practice and application of guidelines[4].

In addition to basic CPR and defibrillation, several drugs may be utilized in advanced cardiac life support (ACLS) with the aim of improving the probability of ROSC. Adrenaline, which was initially tested for effectiveness in dogs in the 1960s, has been recommended for use in ACLS algorithms for decades despite a paucity of good quality evidence in humans. Since then, a large randomized control trial comparing adrenaline to placebo in OHCA showed that although there was an increase in achieving ROSC and 30-day survival, "severe neurological impairment was more frequent in the epinephrine group than in the placebo group 31% vs 17.8%"[5]. As with the majority of data on vasopressor use in cardiac arrest, this study was conducted in a high-income setting. Few studies have been conducted in the in-hospital setting (n=5 of 89); with all of these studies suggesting limited significance of improved outcome from vasopressor usage[6]. Although the AHA recommends the use of antiarrhythmic drugs in resuscitation, their use is controversial due to few high-powered studies on their impact on resuscitation

outcomes. Controlled trial data suggest that there is no significant difference in outcome (ROSC or long-term survival) when amiodarone or lidocaine were compared to each other or to placebo for refractory shockable rhythms in cardiac arrest[7]. Despite the widespread use of drugs in cardiac arrest, an interrogation of the evidence reveals some unfavorable results that should be taken into consideration when using them.

In 2019, the AHA suggested that either "BVM or advanced airway management could be considered in any setting during adult CPR"[8]. Additional procedures such as invasive airway management, with Endotracheal Tube (ETT) or Laryngeal Mask Airway (LMA), take additional time to perform and thus tend to reduce the cardiac compression fraction and in turn the efficiency of CPR. No association between early versus late intubation and either ROSC or 24-hour survival was demonstrated [9]. In fact, "ROSC declined from 50.7% in the first minute to 49.2% after the tenth minute" of time to invasive airway placement thus demonstrating that early invasive airway placement did not result in a significant improvement in outcome [9]. Furthermore, no significant difference in outcome was shown between supraglottic device, endotracheal intubation, and Bag Valve Mask (BVM) [10]. It follows that prioritizing advanced airway management intra-arrest over basic CPR interventions, in some instances, may be to the patient's detriment. However, this may depend on the underlying cause of cardiac arrest as well as the provider's experience.

The role of the provider is crucial to the success of the resuscitation. Factors such as the knowledge, attitudes and experience of providers may directly influence their performance of good quality CPR. Knowledge of CPR guidelines significantly impacts the quality of chest compressions[11] - particularly that of rate and hand placement which, together with depth and recoil, are paramount for good quality chest compressions and effective CPR. However, despite the relationship between performance and knowledge, overall performance of CPR by health providers, irrespective of their level of experience, is poor. This is particularly concerning as good quality CPR – when compared to poorly performed CPR – has been shown to increase survival to hospital discharge by 17% , and substandard CPR has been shown to be as effective as no CPR in improving survival from cardiac arrest. Furthermore, the

knowledge and skill retention of providers declines rapidly over time with motor skills declining faster than knowledge[12]. This reinforces the need for regular practice and training of providers.

Over and above these factors, the impact of patient factors on resuscitation outcomes should not be overlooked. In the United States, most in-patient cardiac arrests occur in males aged 65-70 who have underlying comorbidities and occur most commonly in patients admitted for primary cardiac pathologies (33% of in-patient cardiac arrests)[2]. Several patient factors, independent of sex, such as older age and cardiac co-morbidities are associated with a reduced probability of survival post-resuscitation. In addition to the demographic characteristics of the patient, the first monitored intra-arrest rhythm is a major predictor of resuscitation outcome. ROSC and survival to hospital discharge have been shown to occur less frequently when the initial rhythm was Pulseless Electrical Activity (PEA) or Asystole as compared to Ventricular Fibrillation (VF) or Ventricular Tachycardia (VT). Patients with an unwitnessed PEA or asystolic cardiac arrest greater than 10 minutes duration are unlikely to survive[4]. Intriguingly, although females are more likely to survive cardiac arrest, more men (24%) than women (16%) present in shockable rhythms[13] which are typically associated with a more favorable outcome. This illustrates the paradoxical relationship of gender on resuscitation outcomes.

Identification of the underlying cause is particularly important in a cardiac arrest presenting with PEA rhythm. Historically, providers have been taught the mnemonic "4Hs and Ts" as a memory prompt for the reversible causes of cardiac arrest; however, this list is not exhaustive. Hypoxia (57%), myocardial infarction (53%) and pulmonary embolism (43%), followed by hypovolemia (31%) and acidosis (29%), were the most common causes for a PEA cardiac arrest and it is estimated that in over 65% of PEA cardiac arrests hypothermia, hyperkalemia, toxins and tension pneumothorax are not implicated. Regardless, the less prevalent causes – such as toxins – should not be overlooked as they may be associated with higher rates of survival (at 6 months) when treated (67%)[14].

Use of ultrasound in peri-resuscitative evaluation of patients is becoming more common amongst emergency practitioners because of its ability to correctly identify reversible causes in PEA cardiac arrest (cardiac tamponade, pulmonary embolism, hypovolemia and tension pneumothorax) [15]. However, its impact on resuscitative outcomes has not been comprehensively studied and further training of

nonexpert providers should be provisioned so that quality of resuscitation is not impaired by performance of ultrasound.

The WHO first reported the global pandemic of coronavirus disease 2019 (COVID-19**)** on 31 December 2019. To date, it has had a devastating impact on many lives and health care systems due to the high burden of disease. Although respiratory presentations are the most common manifestation of the disease, case studies of occurrences involving almost all other organ systems have been described. The implications of the pandemic on resuscitative care have been significant, with practices having changed both internationally and locally due to the inherent increased risk of transmission to the provider from aerosolizing procedures central to resuscitative care. To mitigate this, the AHA recommendations included: reduction of the number of providers involved in resuscitative care, wearing of personal protective equipment (PPE) before attending to patients in need of resuscitation, prioritizing early advanced airway management to lower the risk of aerosolization during ventilation (inclusive of early intubation of patients in cardiac arrest) as well as a consideration of the appropriateness of commencing or terminating CPR in patients where resuscitation is unlikely to result in favorable outcome and poses an unnecessary risk to the provider[16].

There is a large body of literature on resuscitative medicine. Nonetheless, there are still gaps in our knowledge base. Recurrent cardiac arrest is understudied due to its relatively low incidence[17], and studies that exist on the impact of drug therapy on outcomes in cardiac arrest are under powered[18]. There is limited information on resuscitation outcomes in the resource limited in-hospital setting such as in low- and middle-income countries. Therefore, the present study will investigate resuscitation outcomes at a public emergency department in Johannesburg as well as the factors that influence these outcomes.

OBJECTIVES

Primary Objectives

1. To describe the characteristics of patients presenting in cardiac arrest to the Emergency Department or developing cardiac arrest whilst in the Emergency Department at a public urban, tertiary level hospital in Johannesburg
2. To describe the management and outcomes of patients who received resuscitation in cardiac arrest in the Emergency Department
3. To compare the clinical characteristics and management between patients that achieved ROSC post-resuscitation and those that demised in the Emergency Department
4. To describe the airway management of patients in cardiac arrest and compare causes and outcomes.

Secondary Objectives

1. To compare and contrast resuscitation outcomes and characteristics before and after the onset of the COVID pandemic
2. To evaluate the adequacy of the CPR registry at Helen Joseph Emergency Department in terms of both completeness of data and accuracy of data.

METHODS

A monocentric retrospective descriptive study will be conducted over a period of 1 year from 01-Jan-2020 to 31-Dec-2020 at Helen Joseph Hospital with the goal of gaining insight into resuscitation practices and outcomes in cardiac arrest in the Emergency Department (ED).

Helen Joseph Hospital (HJH) is a tertiary level public hospital located in Auckland Park, Johannesburg. It is a 601 -bed facility that drains regions B and C as well as parts of region A of the City of Johannesburg. The ED is staffed by 3 consultants, 3 registrars, 15 medical officers, 4 Community Service Medical Officers and 4 interns and sees an average of 5500 patients per month. The hospital typically does not provide care to paediatric and / or obstetrics and gynaecology patients owing to a

nearby mother and child hospital dedicated to their care. The ED makes use of AHA guidelines as the basis of its resuscitation practices.

Data for analysis will be collected from an existing "Resuscitation in Cardiac Arrest Registry" of routinely collected information at HJH ED. Appendix A will be used for data collection. No data will be excluded. Instead, where data is incomplete, the missing data will be entered as "not recorded". The data will be entered and analyzed from a collated data collection sheet (Appendix B) modelled after the parameters of the Utstein-Style Recommended Guidelines for standardized reporting of cardiac arrest. Convenience sampling will be used to achieve a target sample size of 90 (effect size 0.6, significance level 0.05, power 0.8) for the file review.

In addition, the registry will be assessed for completeness and accuracy of data to evaluate its quality. The registry data collection forms (appendix A) will all be analyzed to assess for completeness, where a form will be considered incomplete if data fields have been left blank .To assess the accuracy of data in the registry, forms will be selected at random and compared to the original patient records. Access to the patient records will be gained from the Record Keeping Department at Helen Joseph Hospital. To determine the sample size of records to be reviewed, survey sample methodology will be employed with a confidence level of 95%, an expected proportion of 0.95 and a confidence interval of 0.05. Data contained in the registry will be considered inaccurate if it differs from the original patient records. Any trends and discrepancies noted through this analysis will be discussed.

Permission to conduct this study will be obtained from the CEO of HJH and the HOD of HJH ED once provisional ethics approval has been granted by the University of the Witwatersrand Human Research Ethics Committee (medical).

DATA ANALYSIS

Microsoft Excel will be used to capture data and for basic statistical calculations. Further statistical analysis will be performed using SAS version 9.2. Numerical parametric data, namely age, will be described by mean and standard deviation. Percentages will be used to describe the categorical data. To

compare clinical characteristics to survival outcome, the Fischer exact test will be used. A p value of <0.05 will be considered as statistically significant with a 95% confidence interval.

ETHICS

Ethical approval will be obtained from the University of the Witwatersrand Human Research Ethics Committee (medical) prior to commencing data collection. Anonymity will be assured through the omission of patient details such as name and folder number when collecting information from the existing registry onto the data collection sheet (Appendix B). The data will be stored securely on a personal password protected computer, accessible to the primary researcher only.

TIMING

Data collection will commence from the date of ethics approval

GANTT chart for research and thesis

Task	Months																		
	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021
Literature review																			
Preparing Protocol																			
Protocol assessment																			
Ethics Application																			
Data collection																			
Data analysis																			
Writing up – thesis																			
Writing up – paper																			

FUNDING

Costs incurred during the performance of this study will be minimal. Printing will be done at the Department of Emergency Medicine offices and additional costs, such as travel costs to the study site, will be borne by the researcher.

LIMITATIONS

Possible lack of required data to complete the data collection sheet (Appendix B) from the existing "Resuscitation in Cardiac Arrest Registry" may be a challenge which may compromise the statistical significance of the results. To mitigate this, a period of a year or a minimum of 100 patients, has been chosen in anticipation that this will allow for sufficient data to analyze. There are no other significant issues at this point.

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Appendix C: Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Cathryn Sarah Martin

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M210219

NAME: (Principal Investigator)	Dr Cathryn Sarah Martin
DEPARTMENT:	Family Medicine Division of Emergency Medicine Helen Joseph Hospital - Emergency Department
PROJECT TITLE:	Practices and Outcomes of Resuscitation in cardiac arrest at a South African Emergency Department
DATE CONSIDERED:	26/02/2021
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr P. Saffy and Dr C. Lewis
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	09/03/2021

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

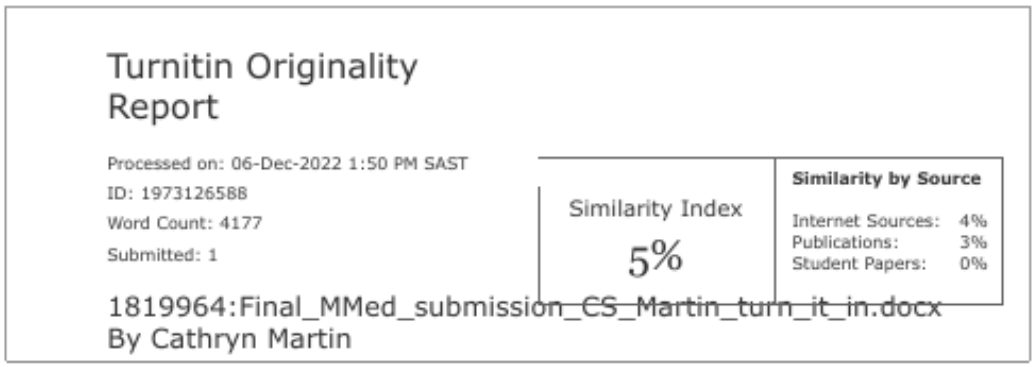
DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **February** and will therefore be due in the month of **February** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature _____ Date _____

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix D: Turn-it in Report



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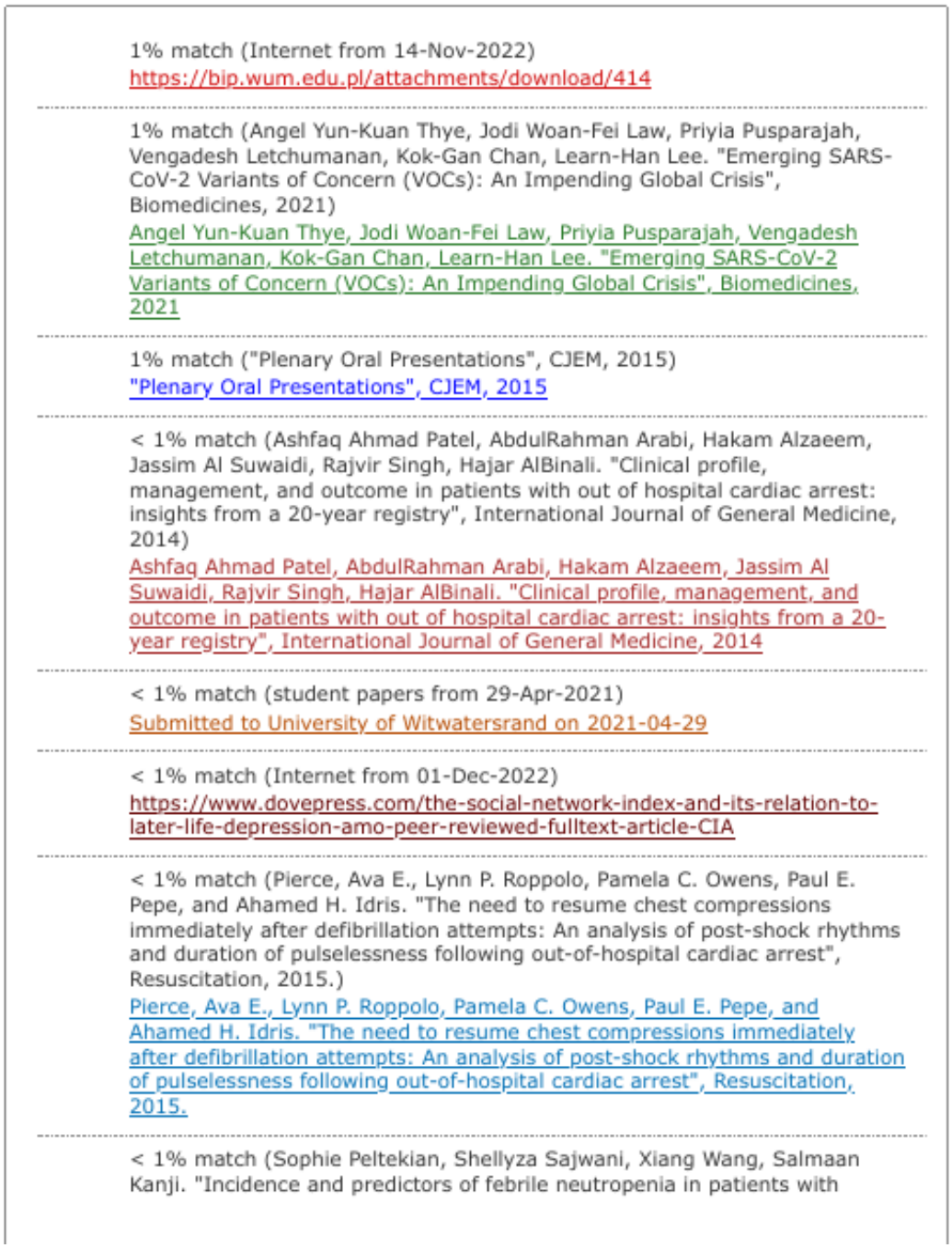
By Cathryn Martin



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Practices and Outcomes of Resuscitation in Cardiac Arrest at a South African Emergency Department Dr Cathryn Sarah Martin Student Number: 1819964 Degree: MMed Emergency Medicine ORCiD no: 0000-0003-1345-598X Supervisors: Dr Carolyn Lewis, MBChB(UCT), FCEM(SA), MMED(UKZN), DipROM(RCSEd), DipPEC(SA), ORCiD no: 0000-0001-9938-7433 Dr Patricia Saffy, MBBCh(WITS), FCEM(SA), MSc(Med) in EM, DipPEC(SA), DA(SA), ORCiD no:0000-0002-6002-4712 ABSTRACT Objectives: This study aimed to investigate the patient and resuscitation factors affecting outcome after cardiac arrest in the low-middle income setting. Methods: We retrospectively reviewed the data of patient's aged