ORIGINAL ARTICLE

Characteristics, management process, and outcome of patients suffering in-hospital cardiopulmonary arrests in a teaching hospital in Hong Kong

CME

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Objectives To examine the demographics, process indicators of adult in-hospital cardiopulmonary arrest resuscitation, and outcomes in a teaching hospital in Hong Kong.

Design Retrospective study.

Setting A university-affiliated tertiary referral hospital with 997 acute adult beds in Hong Kong.

Patients Those who suffered a cardiopulmonary resuscitation event, as documented in retrieved records of all in-patients during the inclusive period January 2002 to December 2005.

Results There were 531 resuscitation events; the mean (standard deviation) age of the corresponding patients was 70.7 (15.4) years. Most (83%) occurred in non-monitored areas and most (97%) were cardiopulmonary arrests. The predominant initial rhythm was asystole (52%); only 8% of patients had ventricular tachycardia/fibrillation. All the resuscitations were initiated by on-site first responders. The median times from collapse to arrival of the resuscitation team, to defibrillation, to administration of adrenaline, and to intubation were: 5 (interquartile range, 2-6) minutes, 5 (1-7) minutes, 5 (3-10) minutes, and 9 (5-13) minutes, respectively. The overall hospital survival (discharge) rate was 5%. The survival rate was higher among patients in monitored areas (9 vs 4%, P=0.046), among patients with isolated respiratory arrests (61 vs 3%, P<0.001), primary ventricular tachycardia/fibrillation arrests (13 vs 4%, P<0.001), shorter interval times from collapse to medication (1.5 vs 5 min, P=0.013), and longer interval times to intubation (12 vs 8 min, P=0.013).

Conclusion Hospital survival after in-hospital cardiopulmonary arrests was poor. Possible strategies to improve survival include shorten time interval to defibrillation, and provision of more monitored beds.

Key words
Cardiopulmonary resuscitation; Emergency Service, hospital; Heart arrest; Survival rate; Treatment outcome

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Introduction

Despite some improvement in recent years, the outcome after in-hospital cardiac arrest remains poor. Prior to 1985 the reported survival rate was approximately 15%,[1-3] whereas since 1990 rates have ranged from 17 to 40%.[4-15] This apparent improvement in survival may be the result of advances in resuscitation techniques, improved education and training, and more effective organisation of the resuscitation process. However, the improved survival rates may also reflect case mix factors like the inclusion of isolated respiratory arrests under the umbrella of cardiac arrest, changes in disease patterns, and increasing rates of 'do not resuscitate' (DNR) orders.[9] More uniform documentation and reporting practices may also have contributed to a change in observed survival rates.

To date, there are few data detailing the process or outcome of in-hospital cardiac arrest in Hong Kong. The aim of this audit was to document the demographics, process indicators, and outcome of adult in-hospital cardiopulmonary arrests in a large teaching hospital in Hong Kong.

Methods

Setting

The Prince of Wales Hospital is a university-affiliated tertiary referral hospital with 997 acute adult beds. There is a 20-bed mixed medical-surgical intensive care unit (ICU). In addition, there are 18 high care, monitored beds, which are located in the following four areas within the hospital: coronary care unit (CCU), medical high dependency unit (HDU), cardiac HDU, and neurosurgical HDU. These high care units are equipped with facilities and nursing staff for invasive haemodynamic monitoring and may offer limited non-invasive ventilator support. Mechanical ventilation for intubated patients is only provided in the ICU.

Resuscitation process

A designated resuscitation team attends every (adult) cardiopulmonary arrest in the hospital and provides advanced cardiac life support. Arrests occurring in the accident and emergency department, ICU, and operating rooms are managed by the respective specialists on-site; the hospital resuscitation team is not activated.

The hospital resuscitation team consists of a senior anaesthesia resident or specialist, and a specialist physician in internal medicine. These team members carry designated resuscitation pagers and proceed promptly to the location of the arrest on receipt of the resuscitation call. Before arrival of the resuscitation team, the on-site ward staff (nurses, the intern, and resident or registrar in-charge) commence basic cardiopulmonary resuscitation (CPR). Emergency trolleys equipped with a cardiac monitor, defibrillator, emergency drugs, and basic airway equipment are available in each ward.

To facilitate a prospective audit, a CPR record form based on the Utstein template[16] was implemented in the year 2000. The form was completed each time the resuscitation team was called. Information relating to patient demographics, admission diagnoses, the time, day, location, and suspected immediate precipitating event for the arrest, the start and finish time of the resuscitation, all medications administered and interventions performed, as well as outcome, was recorded on the form. Immediately after the event, the resuscitation team leader and the nurse in-charge reviewed this information for accuracy. The original form remained in the patient's record and a copy was sent to the hospital's CPR coordinator for audit.

Management after cardiopulmonary resuscitation

Patients with return of spontaneous circulation (ROSC) were assessed for admission to the ICU or high care units for further care. Given the number of ICU and high care beds available, universal access to these facilities could not be guaranteed. In situations where an individual's benefit from further organ support was considered small, consideration was given to conservative therapy. Further management of these patients was in the wards. Although these were difficult decisions, generally there was agreement between relatives, doctors, and nurses on the appropriate course of action.

'Do not resuscitate' policy

In our hospital, DNR decisions were made on an individual basis, if CPR was considered unlikely to benefit the patient. The decision was fully discussed with the patient or their relatives and clearly documented in the case records by the relevant medical staff.

Data acquisition

We reviewed the CPR record forms of all adult patients aged 18 years or above who experienced a resuscitation event during their hospital stay from January 2002 to December 2005. A resuscitation event

於留院期發生心跳呼吸停止的病人特點、救治措施和結果——香港一所教學醫院的經驗

目的 檢視香港一所教學醫院，在留院期發生心跳呼吸停止的成年病人與人口數據有關的資料、進行心肺復蘇的過程指標以及結果。

設計 回顧研究。

安排 香港一所大學附屬有997張成人病床的三級轉介醫院。

患者 2002年1月至2005年12月期間留院紀錄顯示曾接受心肺復蘇的病人。

結果 該段期間共531宗的復蘇事件。該批病人平均年齡70.7歲，標準差為15.4歲，事件多數(83%)在無監測地帶發生，而大部分(97%)為心跳呼吸停止。最主要的初始心搏為心室停搏(52%)，只有8%的病人為室性心動過速/心室纖顫。所有心肺復蘇均在當場由一線救護人員即時進行。由病人出事至心肺復蘇小組抵達、除顫、輸注腎上腺素、插管的時間中位數按序分別為5（四分值域：2-6）分鐘、5(1-7)分鐘、5(3-10)分鐘、9(5-13)分鐘。整體存活（出院）率為5%。存活率較高的病人分別是在監測地帶出事的（9%比4%，P=0.046），單純呼吸停止（61%比3%，P<0.001），原發室性心動過速/心室纖顫（13%比4%，P<0.001），從出事至救治間距時間較短的（1.5比5分鐘，P=0.013），從出事至插管間距時間較長的（12比8分鐘，P=0.013）。

結論 院內發生心跳呼吸停止的病人存活率低。縮短出事至除顫的時間，以及增加受監測床位是提高存活率的可行措施。

TABLE 1. Patient demographics and clinical features*

Demographics	All patients, n=531	Survivors, n=24	Deaths, n=507	P value†
Mean age (standard deviation) [years]	70.7 (15.4)	65.9	70.9	0.115
Gender				
Male	311 (59)	14	297	1.000
Female	220 (41)	10	210	
Specialty				
Medicine	417 (79)	21	396	0.828
Surgery	57 (11)	2	55	
Others	57 (11)	1	56	
Admission diagnosis‡				
Ischaemic heart disease	99 (19)	7	92	0.264
Other cardiovascular diseases	67 (13)	6	61	
Diabetes mellitus	145 (27)	8	137	
Pneumonia	51 (10)	0	51	
COPD	30 (6)	1	29	
Other pulmonary disease	14 (3)	0	14	
GI bleeding	23 (4)	0	23	
Sepsis	58 (11)	1	57	
Chronic renal failure	22 (4)	1	21	
Neurological disease	45 (8)	4	41	
Malignancy	58 (11)	4	54	
Trauma	23 (4)	0	23	
Liver disease	6 (1)	0	6	
Other GI disease	11 (2)	0	11	
Others	20 (4)	0	20	
Unknown	4 (1)	0	20	

* **Data are shown in number, with % in brackets; unless otherwise stated**
† **P value compares survivors and non-survivors**
‡ **COPD denotes chronic obstructive pulmonary disease, and GI gastro-intestinal**

was defined as an event that elicits an emergency resuscitation response by the hospital resuscitation team and the completion of a resuscitation record form. Such events included cardiopulmonary arrest that required chest compressions and/or defibrillation, or acute respiratory compromise leading to cardiopulmonary arrest, or isolated respiratory compromise that only required emergency-assisted ventilation. The CPR record form contained the necessary information to enable evaluation of the in-hospital event resuscitation management. Hospital mortality data and date of death were acquired from the computerised hospital database.

Statistics

Data analysis was performed using Statistical Package for the Social Sciences (SPSS Windows version 14.0; SPSS Inc, Chicago [IL], US). Continuous data were presented as means±standard deviations if they were distributed normally and compared using Student *t* test. Continuous data that were not normally distributed were presented as medians with interquartile ranges (IQRs) and compared using the Mann-Whitney *U* test. Categorical data were presented as percentages and compared by the Chi squared test or Fisher's exact test, as appropriate. All P values were two-sided. A P value of <0.05 was considered significant.

Results

In the defined period, there were 312 861 adult hospital admissions and 531 resuscitation events resulting in a resuscitation team response. Over the same period, there were 5769 in-hospital deaths, of which 5103 occurred in the general wards and monitored areas, and 666 in the ICU, accident and emergency department, and operating rooms.

Demographic and clinical information (including location, characteristics and outcomes of the arrest) that pertained to patients for whom the resuscitation team was activated is summarised in Tables 1 and 2. A total of 166 (31%) of these patients

TABLE 2. Patient cardiopulmonary arrest characteristics and outcomes*

Characteristic	All patients, n=531	Survivors, n=24	Deaths, n=507	P value†
Area				
Monitored	90 (17)	8	82	0.046
Non-monitored	441 (83)	16	425	
Types of arrests				
Cardiopulmonary	513 (97)	13	500	<0.001
Isolated respiratory	18 (3)	11	7	
Initial rhythm‡				
VT/VF	40 (8)	5	35	<0.001
Asystole	274 (52)	1	273	
PEA	103 (19)	0	103	
Bradycardia	72 (14)	6	66	
Others	42 (8)	12	30	
Time of day				
0800-1600	234 (44)	15	219	0.145
1600-2400	97 (18)	4	93	
0000-0800	200 (38)	5	195	

* Data are shown in number, with % in brackets
† P value compares survivors and non-survivors
‡ VT/VF denotes ventricular tachycardia/fibrillation, and PEA pulseless electrical activity

TABLE 3. Process indicators of cardiopulmonary resuscitation (CPR) associated with survival till hospital discharge

Process indicator	Median (interquartile range) [minutes]			P value
	Total	Survivors	Deaths	
Interval to CPR, n=510	0 (0-1)	0 (0-0)	0 (0-1)	0.148
Interval to team arrival, n=506	5 (2-6)	5 (3-8)	5 (2-6)	0.298
Interval to medication administration, n=465	5 (3-10)	1.5 (0-5)	5 (3-10)	0.013
Interval to endotracheal intubation, n=327	9 (5-13)	12 (9.5-24.5)	8 (5-13)	0.013
Interval to defibrillation (for primary VT/VF*), n=39	5 (1-7)	5.5 (0-7)	5 (1.5-9)	0.768
Duration of resuscitation process, n=483	22 (15-30)	9 (4.5-35)	23 (16-30)	0.031

* VT/VF denotes ventricular tachycardia/fibrillation

TABLE 4. Post-arrest patient management and outcomes

Outcome*	Patients No. (%)
Reasons for terminating CPR (n=531)	
ROSC†	145 (27)
No ROSC	386 (73)
Post arrest management (n=145)	
Admission to ICU or other high care unit	56 (11)
Continued management in ward	89 (17)
Outcome at hospital discharge (n=531)	
Survived	24 (5)
Died	507 (95)

* CPR denotes cardiopulmonary resuscitation, ROSC return of spontaneous circulation, and ICU intensive care unit
† For more than 20 minutes

had a diagnosis of cardiac disease on admission to hospital. The majority (83%) of events occurred in non-monitored areas, mostly (79%) under the care of medical specialists. Most (97%) were cardiopulmonary arrests; isolated respiratory arrests were rare (3%). The predominant initial documented rhythm was asystole (52%); only 40 (8%) patients presented with ventricular tachycardia/fibrillation (VT/VF) arrests.

The process indicators for the corresponding resuscitation events and their association with survival are shown in Table 3.

Post-arrest patient management and outcomes are presented in Table 4 and in 'Utstein' format in the Figure. Altogether 145 (27%) patients had ROSC, of whom 56 were subsequently transferred to the ICU or other monitored areas, and 89 continued to stay in

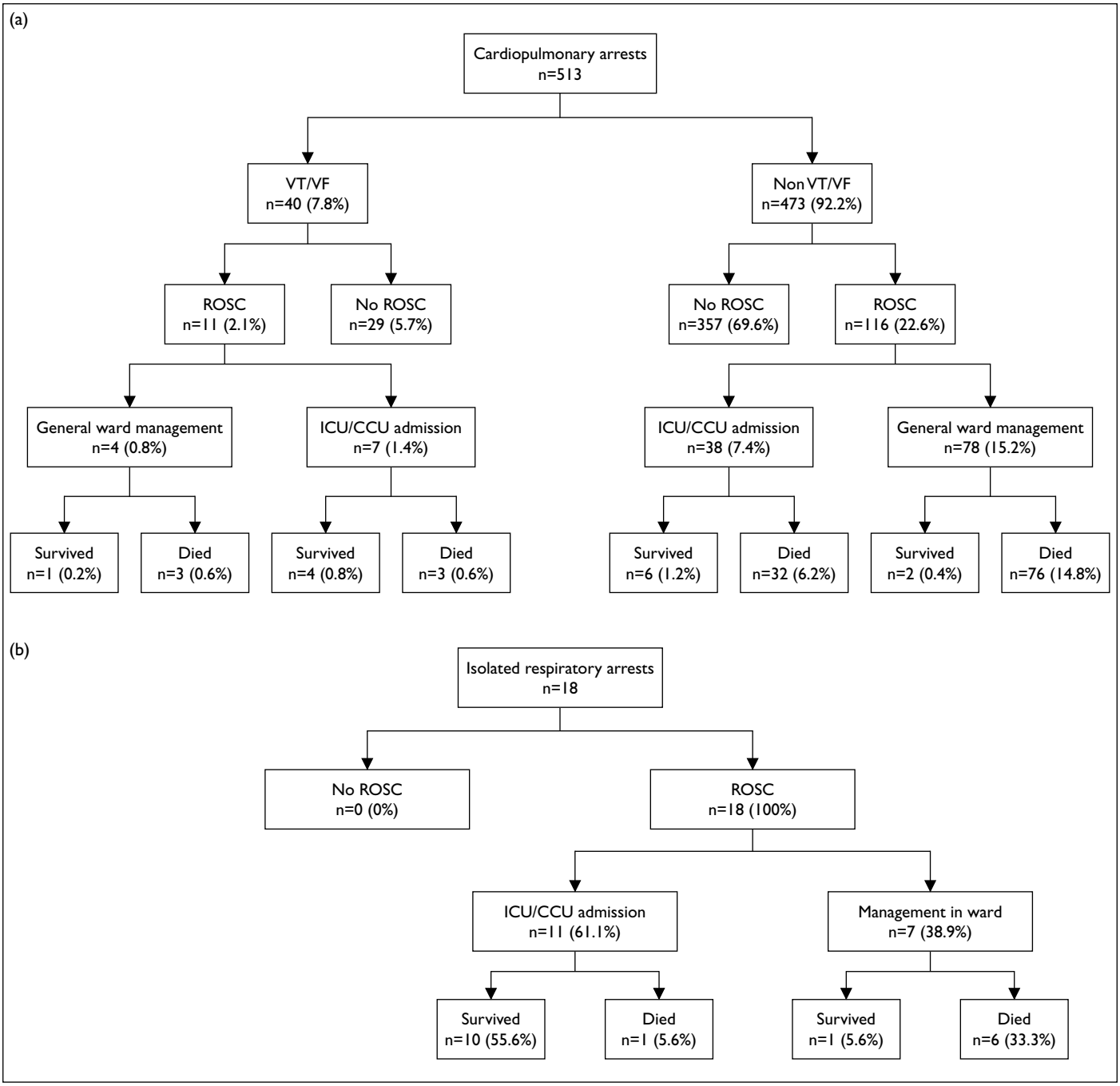

FIG. (a) Outcomes of patients with cardiopulmonary arrests (excluding isolated respiratory arrests). (b) Outcomes of patients with isolated respiratory arrests

CCU denotes coronary care unit, ICU intensive care unit, ROSC return of spontaneous circulation, and VT/VF ventricular tachycardia/fibrillation

the general wards. The rate of survival till discharge from hospital was higher in the former group (36% vs 4%, P<0.001). Overall 24 (5%) of the patients survived to hospital discharge; after excluding patients with isolated respiratory arrests, the hospital survival rate was only 3%.

The rate of hospital survival till discharge was higher among patients who presented with isolated respiratory arrest (61 vs 3%, P<0.001), VT/VF (13 vs 4%, P<0.001), and for patients whose arrests ensued in monitored areas (9 vs 4%, P=0.046). Among the process indicators, the time interval from collapse to medication administration was significantly shorter in survivors than non-survivors (1.5 vs 5 min, P=0.013), but the interval to tracheal intubation was significantly longer in survivors than in non-survivors (12 vs 8 min, P=0.013). The median duration of resuscitation was shorter in survivors than in non-survivors (9 vs 23 min, P=0.031).

Discussion

This audit revealed a poor survival rate of only 5% after in-hospital cardiopulmonary arrests in a large teaching hospital in Hong Kong. The survival rate was higher among patients with isolated respiratory arrests, primary VT/VF arrests, those who arrested in monitored areas, and in whom the time interval from collapse to medication was shorter and the time interval from collapse to intubation was longer.

The initial rhythm was VT/VF in only 8% of our patients, which is much lower than previously reported rate of between 25 and 50%.[5,6,10,11,15] Because VT/VF arrests are associated with a better survival than asystole/pulseless electrical activity, the low incidence we encountered may partly explain our low survival rate. It is possible that the real VT/VF rate was actually somewhat higher, because VT/VF occurring in CCU patients could sometimes result in immediate defibrillation by nurses or cardiologists. Thus, rapid ROSC may not have resulted in activation of the resuscitation team. These omissions would reduce the overall rate of reported VT/VF arrests. However, the true VT/VF rate was probably still low. Our low VT/VF incidence may also reflect a delayed diagnosis of cardiac arrest; the initial rhythm being unrecognised until degenerating to asystole. Alternatively, it may represent a real difference in the primary type of cardiac arrest in our patients. The former hypothesis seems more plausible for two reasons. First, most (83%) of the arrests occurred in non-monitored areas, predisposing to a greater delay from collapse to electrocardiogram recording. Second, many (31%) of our patients had a primary diagnosis of ischaemic heart disease or some other cardiac disorder, and were therefore more liable to develop VF than non-cardiac patients.[17]

The hospital survival rate of our patients who presented with VT/VF was 13%, which is also lower than the rates reported in recent series, which ranged from 34 to 57%.[4,5,7,8] One possible determinant of such a poor outcome was the time interval from collapse to defibrillation. The median time to defibrillation of 5 minutes, being considerably longer than that reported in the American National Registry of Cardiopulmonary Resuscitation[5] and a recent Swedish study[6] which reported median time to first shock of 0 minutes (IQR, 0-2) and 2 minutes, respectively. There is evidence that outcome is improved when the first shock is delivered within 3 minutes,[18] indicating considerable scope for improvement in our setting. Outside the ICU and CCU, although our hospital nurses are the first responders, currently they must await the arrival of a doctor or the resuscitation team to provide defibrillation, as they are not trained to deliver such treatment. Introduction of automated external defibrillators (AEDs), and/or additional training for nurses could overcome this problem. In-hospital use of AEDs by non-ICU nurses and other first responders was first described in 1995,[19,20] and its routine in-hospital use is supported by recent studies.[21,22]

As in previous studies,[8,11,15] our findings showed that patients who suffered a cardiac arrest in monitored areas enjoyed better hospital survival. Such outcomes may be related to higher rates of witnessed arrests, shorter time interval from collapse to defibrillation, and earlier anticipation due to premonitory symptoms and signs.[11] Arguably, having more monitored or critical care beds could prevent cardiac arrests and improve outcomes if they ensue. However, in our study only 17% of cardiac arrests occurred in such areas, whereas in other studies the figure ranged between 32 and 65%.[6,8,14,15] The number of high care monitored beds in our hospital is only 18, and the number of ICU beds is 20. This number of ICU beds constitutes 1.6% of all acute care beds, a ratio that is substantially less than prevailing ratios in the United States (6%), Germany (35%), Belgium (3%), or Australia (3.7%).[23]

Timely institution of effective CPR can help to improve the outcome of in-hospital cardiac arrests.[15] In our study, the median response time of the resuscitation team members was 5 minutes, and accounts for a substantial delay in terms of the more advanced aspects of resuscitation. This delay may be related to the fact that the resuscitation team members have other concurrent acute medical responsibilities. In a recent study in Italy,[15] the arrival time of the cardiac arrest team in non-monitored areas was 3.98±1.73 minutes; the arrival time being significantly shorter in survivors (1.30±1.70 min) than non-survivors (2.51±2.37 min). The authors suggested that a faster cardiac arrest response and early defibrillation by the ward staff are the most important improvements that could increase cardiac arrest survival in their setting.[15] A similar conclusion might also be applicable in our setting.

Ours is one of the few hospitals in Hong Kong that has a formally organised CPR team to respond to hospital-wide calls for resuscitation. There is, however, some variability in the professional training and experience of team members; not all of them have Advanced Cardiac Life Support (ACLS) or equivalent certification. While resuscitation teams are very common in the United States,[5] and appear to be desirable,[24] it is not clear as to whether they improve outcomes.[17] Since there is a delay in arrival of the resuscitation team, it is imperative that first responders in the wards start effective CPR. Not surprisingly, arrest discovery and immediate resuscitation by nurses trained in ACLS has been associated with higher survival rates,[25] and such benefits have also been associated with institution of

broad ACLS training programmes.[26,27] In our hospital, resuscitation training for ward nurses was regularly provided, though most of them do not have ACLS or equivalent certification.

The positive association between short time intervals to medication and favourable outcome may reflect earlier response times and the benefits of aggressive early resuscitation with vasoactive drugs. The negative association between intubation interval and good outcome is consistent with the observation that hyperventilation is common in resuscitation, especially after intubation, and that hyperventilation is potentially detrimental in patients with low output states.[28,29] Another possibility is that undue focus on tracheal intubation leads to prolonged interruption in chest compression, which is vitally important for neurological recovery.[30,31] We also noted that the duration of resuscitation is significantly shorter in survivors than non-survivors, suggesting that those who were destined to survive respond more promptly to resuscitation efforts.

The implementation of DNR orders may also have had an impact on survival. For patients with multiple medical problems with little or no chance of survival with an acceptable quality of life, DNR orders can prevent unwarranted, futile, and undignified attempts at resuscitation. The aggressiveness with which an individual hospital withholds resuscitation attempts has significant bearing on immediate survival rates.[32] In various reports, DNR policy resulted in resuscitation attempts being instituted for between 6 and 53%[6,10,33-35] of patients who died during the hospital stay. During the study period, 10% (507/5103) of patients who died in the general wards and monitored areas of our hospital elicited a resuscitation team response, which is comparable to recent reports[6,33] and consistent with well-established issuing of DNR orders in our hospital.

Lastly, studies have shown that physiological instability and clinical deterioration usually precede a cardiac arrest, and that general wards often do not have the resources to recognise or meet the needs of these ill patients.[36-39] It has been recommended that all hospitals should create systems to prevent patients from deteriorating and if needed identify and treat those who do so early.[36-39] However, the evidence is equivocal as to how that should be accomplished,[38] in view of the inconclusive and contradictory reports regarding the merits of introducing rapid response/medical emergency teams.[36,37,40] Comprehensive educational programmes, increasing the number of high care monitored beds,[11] and increasing nursing staff numbers are other alternatives.

A limitation of this study was that it was confined to a single centre, and may not reflect the situation in the whole of Hong Kong. Second, arrests occurring in the accident and emergency department, ICU, and operating rooms were not included. Third, although data were prospectively reported on a standardised audit form, data collection was not performed by dedicated observers and up to 12.4% of the data on process indicators were missing. Lastly, because of the small number of patients surviving to hospital discharge, we were unable to perform multiple logistic regression analysis to determine predictors of survival.

Conclusion

Compared to previously published international data, outcome after in-hospital cardiopulmonary arrests in a large university teaching hospital in Hong Kong was poor. Possible factors contributing to such outcomes were identified. Strategies to improve outcomes in our setting include: reducing the time interval from arrest to defibrillation, a faster response time for the resuscitation team, increasing the proportion of ACLS-trained personnel, and improved recognition and monitoring of acutely ill patients, preferably in high care monitored areas or ICUs.

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