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Clinical paper

Direct transport to PCI-capable hospitals after out-of-hospital cardiac arrest in New Zealand: Inequities and outcomes

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Abstract

Background: It is widely accepted that survival from OHCA may be improved through direct transfer of patients to hospitals with percutaneous coronary intervention (PCI) capability. However, within the New Zealand healthcare system there is limited evidence available to support this. We aimed to compare patient characteristics and outcomes following an out-of-hospital cardiac arrest between those patients transported to hospitals with or without PCI-capability within New Zealand.

Method: A retrospective cohort study was conducted using data from the St John New Zealand OHCA registry for adults treated for an out-of-hospital cardiac arrest of presumed cardiac aetiology between 1 October 2013 and 31 October 2018. Population characteristics were investigated using a Chi-Square analysis. Binary logistic regression modelling was used to investigate outcome differences in survival at 30 days post-event according to receiving hospital PCI-capability.

Results: The study included 1750 patients who were transported to hospital following an OHCA. A significantly lower proportion of patients over 65 years (49.9%) were conveyed to hospitals with PCI-capability compared to younger aged patients (15–44 years (52.1%) and 45–64 years (59.7%) ($p < 0.001$). When ethnic groups were compared, Māori (32.9%) had the lowest proportion transported to PCI-capable hospitals, followed by European (55.6%) then Pacific Peoples (86.2%) ($p < 0.001$). A lower proportion of patients located rurally (34.7%) were transported to hospitals with PCI-capability compared to patients in an urban location (59.1%) ($p < 0.001$). Thirty-day survival was higher in patients transported to hospitals with PCI-capability (adjusted OR 1.285, 95%CI (1.01–1.63), $p = 0.04$).

Conclusions: Patient characteristic differences indicate that inequities in healthcare may exist in New Zealand related to age, ethnic group, and rurality. Thirty-day survival was significantly increased in patients conveyed directly to a hospital with PCI-capability.

Keywords: OHCA, Out-of-hospital cardiac arrest, Percutaneous coronary intervention, PCI, Paramedic, EMS, Emergency medical service, Ambulance, By-pass, STEMI

Introduction

Early assessment of coronary artery patency by angiogram, followed by ballooning as necessary, has been shown to improve survival following cardiac arrest.[1–6] These interventions are only available in hospitals that offer percutaneous coronary intervention (PCI). The majority of evidence suggests that direct admission to a PCI-capable facility improves survival for patients following an OHCA.[1,7–9] In general, international guidelines and findings support direct transfer to PCI-capable hospitals following an OHCA. The American Heart Association Guidelines stipulate 'immediate' (within 2 h) PCI for

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patients admitted with return of spontaneous circulation (ROSC) following an OHCA.[10] The European Association for Percutaneous Cardiovascular Interventions recommends similar timeframes.[3] In Perth, Western Australia, ambulance transport of patients following an OHCA to an initial local, non-PCI-capable, hospital added 161 min before arrival at a PCI facility, and was associated with a significant decrease in survival to hospital discharge.[11] In contrast, other studies have found that the PCI-capability of the destination hospital made no difference to survival.[4,12]

It is possible that survival could be influenced negatively by either a prolonged time spent in a non-PCI-capable hospital, or longer transport times due to bypassing the nearest hospital.[11,13] This is of particular relevance to emergency medical services (EMS) in deciding whether patients who achieve ROSC following an OHCA should be transported to the nearest local area hospital (which may not be PCI-capable), or directly to a PCI-capable facility by employing a bypass protocol. In New Zealand there is no national stand-alone protocol that stipulates direct conveyance of patients to a PCI-capable hospital following an OHCA of suspected cardiac cause. However, in some urban areas of New Zealand, the EMS may bypass the nearest hospital if post-ROSC ST-segment elevation is indicated on a 12-lead electrocardiogram. Given the unique population and geography of New Zealand, it remains unknown if international findings and guidelines regarding direct conveyance to a PCI-capable hospital are generalisable to this population.

The aims of this study were to investigate how PCI-capability of the receiving-hospital impacts on survival following adult OHCA in New Zealand, and to determine whether patient characteristics differed between the PCI-capability groups.

Methods

Study design

This was a retrospective cohort study that compared patient characteristics and outcomes between two groups of adult patients with ROSC sustained on arrival at the receiving hospital following an OHCA. The variable of interest was whether the receiving-hospital was PCI-capable.

The study was performed across the country of New Zealand, with the exclusion of the Wellington region. The Wellington region, which contains 10% of the New Zealand resident population, is serviced by the Wellington Free Ambulance service and at the time of the study, data were unavailable for this service.

The St John OHCA Registry

The St John OHCA Registry contains data for all OHCA attended by New Zealand's largest EMS, St John (but excluding events in the Wellington region).[14] Variables collected in the St John OHCA Registry include whether resuscitation was attempted, patient age and sex, arrest aetiology, whether an event was witnessed (EMS or bystander), performance of bystander CPR, community defibrillation, shockable presenting rhythm, EMS response time (time from call pickup in the call-centre to vehicle arriving at the scene), EMS transport time (time from ambulance departing the scene to arrival at hospital), location (aged care/healthcare facility/home/public/other), and geographic location of the event (urban/rural).

Inclusion and exclusion criteria

All patients aged 15 years and older treated for an OHCA between 1 Oct 2013 and 31 Oct 2018 (61 months) were screened for inclusion. Events were included if they were of presumed cardiac aetiology (traumatic arrests were excluded) with ROSC achieved and sustained until handover at the receiving-hospital, irrespective of whether the arrest occurred in the presence of EMS.

PCI-capability

PCI-capability was defined as hospitals having 24/7 facilities available for PCI. Hospitals with partial PCI-capability, for example those where PCI was available during 'office-hours' only, were excluded from this study.

Ethnicity

Patient ethnicity was recorded by the attending ambulance officer at the incident. Ethnicities analysed in this study were: Māori (the indigenous population of New Zealand), Pacific Peoples (people predominantly from South Pacific Islands including Samoan, Cook Islands Māori, Tongan and Niuean), and European. Other residual ethnicities that made up less than 5% of the cardiac arrest registry data were included within the European cohort.[15]

Rurality

Rurality (urban versus rural) was determined by Statistics NZ 2013 Census meshblocks aligned to the address/location of the OHCA event.[16] For the purposes of this study, urban versus rural was defined by the following meshblock descriptors: urban included 'main urban area' and 'secondary urban area', whilst rural included 'minor urban area', 'other rural' and 'rural centre'.[16]

Ministry of Health National Health Index data

Thirty-day mortality data was collected through linkage of the St John OHCA Registry data to National Health Index data.

Ethics

Ethical approval for this study was provided by the New Zealand Health and Disabilities Ethics Committee (No. HDEC 13/STH/192/AM02) and the Auckland University of Technology Ethics Committee (No. 13/367).

Statistical analysis

Variables were described as totals and percentages of total numbers. A Pearson Chi-Squared test (X^2) and the z-test for column proportions was used to compare nominal values. Continuous variables (response time and travel time) were compared using the Mann–Whitney U Test. Binary logistic models were used to investigate outcome differences in survival to 30 days. Data are presented as odds ratios (OR) with 95% confidence intervals (CI). Covariates used in the adjusted models are described within the table descriptions. Data analysis was performed using IBM SPSS (V.25.0). A value <0.05 was considered statistically significant.

Results

In total 1750 patients were included in the analysis, of which 940 (53.7%) were conveyed to PCI-capable hospitals, and 810 (46.3%) were transported to hospitals with no PCI-capability. See Fig. 1.

Population characteristics

A significantly lower proportion of patients over 65 years (n = 470, 49.9%) were conveyed to hospitals with PCI-capability compared to younger aged patients 15–44 years (n = 88, 52.1%) and 45–64 years (n = 382, 59.7%) ($p < 0.001$) (Table 1).

Major differences in receiving-hospital were observed between ethnicities: Māori (n = 79, 32.9%) had the lowest proportion transported to PCI-capable hospitals, followed by European (n = 746, 55.6%) then Pacific Peoples (n = 50, 86.2%) ($p < 0.001$).

System response characteristics

A higher proportion of patients that had received community defibrillation were observed in the PCI-capable destination cohort compared to the non-PCI-capable destination cohort (n = 192, 67.4% versus n = 93, 32.6%, $p < 0.001$).

Ambulance response time was not significantly different between patients transported directly to a PCI-capable hospital versus those that were not (p = 0.92). However, the median transportation time was longer for patients transported directly to PCI-capable hospitals (13 min (IQR 8–20) versus 10 min (IQR 5–20), $p < 0.001$).

A larger proportion of patients whose arrests occurred in urban localities were transported to a PCI-capable facility (n = 759, 59.1%) compared to those in rural locations (n = 131, 34.7%), ($p < 0.001$).

Survival at 30 days

Of the total patients transported to hospital with sustained ROSC after OHCA, 904 survived to 30 days (52.4%). However, a greater proportion of patients survived after transport to PCI-capable hospitals (n = 511, 56.5%) than those transported to a non-PCI-capable hospital (n = 393, 43.5%) ($p < 0.001$). Following adjustment for confounding, patients transported directly to PCI-capable hospitals had significantly higher odds of survival than those patients transported to non-PCI-capable hospitals (OR 1.29, 95%CI (1.01–1.63), p = 0.04), Table 2.

Discussion

Our study shows that the PCI-capability of the receiving hospital was strongly associated with 30-day survival in patients following an OHCA with ROSC sustained to hospital admission in New Zealand. This is in line with international trends and international best practice.[1,7–9] Direct admission to a PCI-capable hospital in New Zealand was associated with age, ethnicity, and rurality.

We identified an association between destination hospital and age, whereby the oldest patients (≥65 years) were underrepresented in the direct to PCI-capable hospital group. One possibility is that there are more elderly living in rural locations, however New Zealand population data does not support this. Both the 45–64 age group and the ≥65 age group have the same proportions of their populations living rurally (both 24% rural/76% urban). Interestingly, the 15–44 age group have a lower proportion of their population in rural areas (17% rural/83% urban).[16] On the other hand, when these populations are looked at by domiciled district health board, there is a lower proportion of those in the ≥65 age group whose domiciled district health board has a 24/7 PCI-capable hospital (49%) compared to those in the 15–44 (54%) or 45–64 (52%) age groups. Therefore locality may indeed contribute to this finding.[17] A similar trend has been observed in transportation to

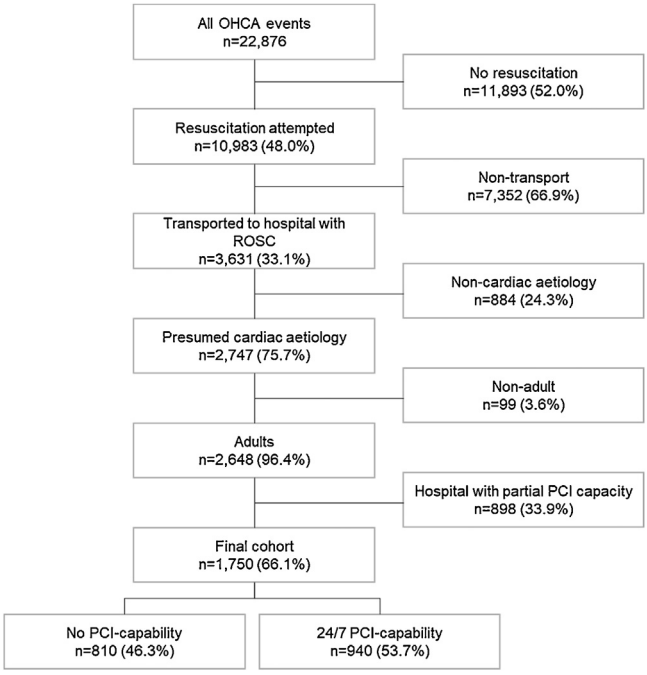

Fig. 1 – Numbers meeting inclusion criteria: adult patients with an OHCA of presumed cardiac aetiology, with ROSC sustained to receiving-hospital, comparing those transported to hospitals with, versus without, PCI-capability.

Table 1 – OHCA characteristics and outcomes by PCI-capability of receiving-hospital (n = 1750).

		Total		No PCI-capability		24/7 PCI-capability		*p Values
		n	%	n	%	n	%	
Population characteristics								
Age	Missing data	0	0%					
	15–44	169	9.7%	81	47.9%	88	52.1%	*0.001
	45–64	640	36.6%	258	40.3%	382	59.7%	
	65plus	941	53.8%	471	50.1%	470	49.9%	
Sex	Missing data	0	0%					
	Female	457	26.1%	226	49.5%	231	50.5%	0.11
	Male	1293	73.9%	584	45.2%	709	54.8%	
Ethnicity	Missing data	111	6.3%					
	European & Other	1341	76.6%	595	44.4%	746	55.6%	*<0.001
	Māori	240	13.7%	161	67.1%	79	32.9%	
	Pacific Peoples	58	3.3%	8	13.8%	50	86.2%	
Utstein variables & system response								
Witnessed status	Missing data	0	0%					
	Yes-EMS	462	26.4%	217	47.0%	245	53.0%	0.53
	No	257	14.7%	126	49.0%	131	51.0%	
	Yes-bystander	1031	58.9%	467	45.3%	564	54.7%	
Bystander CPR	Missing data	3	0.2%					
	No	697	39.8%	329	47.2%	368	52.8%	0.54
	Yes	1050	60%	480	45.7%	570	54.3%	
Community defibrillation	Missing data	0	0.00%					
	No	1465	83.7%	717	48.9%	748	51.1%	*<0.001
	Yes	285	16.3%	93	32.6%	192	67.4%	
Shockable presenting rhythm	Missing data	0	0%					
	No	487	27.8%	239	49.1%	248	50.9%	0.15
	Yes	1263	72.2%	571	45.2%	692	54.8%	
Location	Missing data	0	0%					
	Aged care facility	28	1.6%	14	50.0%	14	50.0%	0.13
	Healthcare facility[a]	72	4.1%	28	38.9%	44	61.1%	
	Home	967	55.3%	469	48.5%	498	51.5%	
	Public	565	32.3%	241	42.7%	324	57.3%	
	Other	118	6.7%	58	49.2%	60	50.8%	
Rurality	Missing data	89	5.10%					
	Urban	1284	73.4%	525	40.9%	759	59.1%	*<0.001
	Rural	377	21.5%	246	65.3%	131	34.7%	
Response time (mins) (median, (IQR))	Missing data	7	0.40%					
	Response time	7 (5–10)		7 (5–10)		7 (5–10)		0.92
Transport time (mins) (median, (IQR))	Missing data	179	10%					
	Transport time	12 (7–20)		10 (5–20)		13 (8–20)		*<0.001
Thirty-day survival	Missing data	24	1.4%					
	No	822	47.0%	414	50.4%	408	49.6%	*0.004
	Yes	904	51.7%	393	43.5%	511	56.5%	

CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation.
* $p < 0.05$ is significant; χ^2 test for nominal values; Mann–Whitney U-test for continuous values.
[a] Healthcare facility refers to non-hospital treatment localities such as a general practice clinic.

Table 2 – Association between PCI-capability and survival to thirty-days (logistic regression).

		Unadjusted OR	95% CI	Sig.	*Adjusted OR	95% CI	Sig.
PCI capability	No PCI-capability (reference)	1			1		
	24/7 PCI-capability	1.32	(1.09–1.60)	<0.001	1.29	(1.01–1.63)	0.04

* Adjusted for: age, sex, ethnicity, witnessed status, bystander CPR, community defibrillation, shockable rhythm, response time, location, rurality. Statistically significant ($p < 0.05$).

the most appropriate hospital for elderly major trauma patients.[18] Given the increase in the aging population, additional research in this area is needed.

Our current study revealed striking ethnic differences in the type of hospital to which New Zealand patients with ROSC were transported. Interestingly, Pacific Peoples had the highest proportion transported direct to a PCI-capable hospital, followed by Europeans, whilst Māori exhibited the lowest proportion of such transports. However, the actual numbers of Pacific Peoples with ROSC was small (n = 58), representing only 3.5% of the total study cohort and therefore these

results should be treated with caution. The ethnic differences seen in the receiving-hospitals may well be confounded by the urban/rural divide. Pacific Peoples are predominantly urban-dwelling: nearly two-thirds live in the Auckland region,[19] New Zealand's biggest urban area with a large 24/7 PCI-capable tertiary facility. By contrast, Māori, though still predominantly urban, are more likely than other ethnicities to live rurally. For example, the Gisborne and Northland regions contain higher percentages of Māori than other regions (48.9% and 32.4% of residents respectively, compared to the New Zealand average of 15%). Neither region has 24/7 PCI-capable facilities.[19] Health inequities are well documented for Māori; rurality is one contributing dimension of this.[20]

For both age and ethnicity, it is likely that the geographic location of the OHCA directly impacts on transport to a PCI-capable hospital. However, this study did not specifically investigate whether there was any bias on the part of attending ambulance crews or whether features of the cardiac arrest (shockable vs non-shockable rhythm, bystander CPR) could have influenced transport destination decisions. All these factors are deserving of future investigation.

Rurality is a straight-forward and obvious factor because 24/7 PCI-facilities in New Zealand are exclusively located in urban areas (i.e. major cities). This reality accounts for the rural/urban divide in PCI-capability of receiving-hospitals. In comparison, larger New Zealand cities have both suburban hospitals without PCI-capability and major tertiary centres with 24/7 capability and also hospitals providing PCI-capability during normal business hours. At the time of this study, if a STEMI was identified post-ROSC in such an urban centre then EMS were able to convey the patient directly to the PCI-capable hospital. There is no evidence in New Zealand as to whether ambulance crews should transport patients with ROSC, but without an indication of a STEMI, direct to the nearest suburban hospital or whether these should be bypassed in favour of a more distant PCI-capable facility. This study supports the bypass model. The difference in median transport time between the PCI-capable and non-PCI-capable hospitals in New Zealand was only three minutes. However, this does not take into account that diversion to a more distant PCI-capable hospital was not an option for rural centres at the time of this study. A similar study in North Carolina also showed a benefit in survival for bypassing non-PCI-capable facilities when the median time to bypass the nearest hospital incurred was only an additional three minutes.[21] Of relevance to our more rural populations, Cournoyer et al. found a survival advantage in bypassing non-PCI-capable receiving-hospitals, so long as the extra transport time did not exceed 14 min.[13] In general, an increase in median transport time from 10 to 13 min is unlikely to disadvantage a patient with ROSC and is likely to increase their chances of 30-day survival through admission to a PCI-capable facility. Whether there was an upper limit to this additional transport time, as proposed by some, could not be determined by our study.[13] Given the geographic spread of rural populations within New Zealand, it will be important to assess whether extended transport times direct to PCI-capable hospitals are of benefit in this setting.

Clearly, in-hospital care affects the survival of out-of-hospital cardiac arrest patients with ROSC sustained to admission. International guidelines have been developed for best practice in the hospital care of these patients,[22–25] and adherence to such guidelines has been shown to improve survival.[26,27] Immediate revascularisation via PCI, where indicated, is prominent among guideline recommendations. Other aspects of care include: treatment of underlying cause, therapeutic hypothermia, optimization of hemodynamics and gas exchange, control of glucose levels, neurologic diagnosis and prognostication.[22,28] The complexity of such targeted management typically requires intensive care facilities, found only in major cities. How best to provide that level of care to the rural patient with ROSC in a timely way warrants further investigation.

Limitations

This study only included 24/7 PCI-capable hospitals; those hospitals with partial 'office-hours' PCI-capability were excluded because it was unclear as to whether PCI was available at the time of patient arrival.

At the time of this study, rural areas had no protocols for EMS to divert to hospitals with PCI-capability, therefore relationships between prolonged transport time in regard to bypass versus no-bypass were unable to be investigated.

It is assumed that the survival improvement was a result of PCI performed at a PCI-capable receiving hospital. However, this was not investigated as part of the study. Tertiary hospitals have more sophisticated support facilities and better resources, including staffing. A better measure of impact would be event-to-balloon times, which can be strongly influenced by delays at a non-PCI-capable local hospital as we have recently shown in (non-arrest) STEMI patients.[29]

Conclusion

Our study has shown that following an OHCA survival to 30 days was enhanced if the patient was directly transported to a 24/7 PCI-capable hospital. However, all 24/7 PCI-capable hospitals are located in major urban centres in New Zealand, and ambulance transport of patients to such facilities revealed inequities associated with age, ethnicity and rurality. Direct transport to a PCI-capable hospital of all patients with ROSC following an OHCA of suspected cardiac aetiology may be one mechanism for reducing health inequities in New Zealand.

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Competing interests

BD and VT are employees of St John.

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