平成20年度(財)救急振興財団調査研究助成事業

日米両地域における病院外心停止症例の生存転帰に基づいた搬送医療施設選定基準開発の為の研究

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報告書

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【背景】

院外心停止からの生存転帰（救命率）に関する検討は、元来、個別の医療施設毎の蘇生治療の結果や、救急隊の活動内容/活動時間から行われてきた。
最近の海外の報告では、心停止現場で蘇生し得た症例に関しては、低体温療法や早期の心臓カテーテル検査などの高度な治療を実施することにより患者転帰を改善したという報告がある。(1-7)しかし一方、患者転帰には病院前の要素(Prehospital factor)のみが関与しており、病院到着後の蘇生内容や、心拍再開後の治療は転帰に影響していなかったという報告や、良好な転帰を得る為には、迅速な直近の救急病院への搬送が効果的であったという報告もある。(8-10)。

我が国においても 2006 年の心肺蘇生ガイドライン改訂以降、高度な専門知識を有する救急蘇生チームへの迅速な引継ぎの効果が示され、地域あるいは施設での効果的な診療体制の構築が求められているが、蘇生治療の内容は日々高度化・複雑化しており、治療対応可能な施設が限定されてきている。また昨今、我が国においては傷病者の受け入れ拒否による不幸な転帰が多く報道され、社会問題にまで発展している。しかしいまだ現場で活動する救急隊員は、心停止患者を二次救命処置が可能な直近の救急医療施設に搬送すべきなのか、搬送時間をかけてでも、より高度な治療が可能な 3 次救急医療施設に搬送すべきなのかについて、生存転帰から考えられた明確な病院選定基準を持ち得ていない。それは受け入れる医療機関側に対しても傷病者の集中化や施設の満床化を招き、受け入れ拒否の原因の一つになっている。

我々は、1998 年 5 月より、大阪府全域(対象人口 880 万人)を網羅する形で救急隊員の関わる全ての院外心停止症例の蘇生に関する記録を国際的に標準化されたフォーマットに基づいて、記録・集計するプロジェクト(ウツタイン大阪プロジェクト)を継続し、院外心停止に関するさまざまな疫学的なデータを報告するとともに、地域の救急システムの検証を行ってきた。本研究では、 この地域を網羅した大規模な院外心停止症例の登録プロジェクトを生かし、救命救急センターに搬送された症例と、その他の救急病院に搬送された症例の患者背景、生存転帰を比較することとした。また同種のデータを蓄積している米国オレゴン州ポートランド市と大阪のデータを比較検討することとした。

【目的】

大阪府全域とポートランド市及び周辺地域(米国・オレゴン州)の両地域における病院外心停止例の受け入れ医療機関別転帰を検討することにより、傷病者の生存転帰を第一に考えた救急隊員による病院外心停止症例の搬送医療機関選定基準を開発すること。

【方法】

研究デザイン:コホート研究(前向き集計、population-based)

対象・サンプリング

1.対象地域:

①大阪府全域(人口880万人、年間院外心停止約5000例)

②ポートランド市及び周辺地域(人口:175万人、年間院外心停止数:1,600例)

2.対象期間:

①2005年1月1日から2007年12月31日

②2005年12月1日から2008年6月30日

3.レジストリ方法:

病院外心停止症例の蘇生記録に関する国際的に標準化されたフォーマットであるウツタイン様式'3,'4)にのっとった記録用紙を作成。 救急隊員の関わるすべての病院外心停止症例の蘇生に関する記録を前向きに集計した。 1 ケ月生存の有無、脳神経学的機能までの蘇生経過に関する情報は、 蘇生に関わった救急隊員が搬送先医療機関の担当医師の協力のもと記録し報告された。

4. 本研究における対象症例の適格基準

以下のすべてを満たすもの:

①18歳以上 ②救急隊により何らかの蘇生が行われたもの

③心原性心停止と判断されたもの ④搬送先病院が特定されたもの

主たる要因(大阪):救命救急センターへの搬送の有無

救命救急センター:3次救急医療機関として厚生労働省に認可された施設。

その他の救急病院:2次救急医療機関。

主たるアウトカム指標:

1、一ヶ月後の神経学的予後(CPC1 or 2) (PortlandではSurvived to discharge)

2、病院到着前の心拍再開、病院内の心拍再開、生存入院、一ヶ月生存の有無

解析方法

救急医療機関に搬送された症例の背景・心肺蘇生の時間経過(年齢、性別、救急通報から現場到着までの時間、救急通報から病院搬送までの時間、心停止の場所、 初期心電図調律、心停止の目撃の有無、電気ショック施行の有無、居合わせた市民による心肺蘇生実施の有無、搬送先病院種別等)を、施設別に分け比較した。統計学的解析はいずれも両側検定、 有意水準:P<0.05とした。
使用ソフトウェア:SPSS

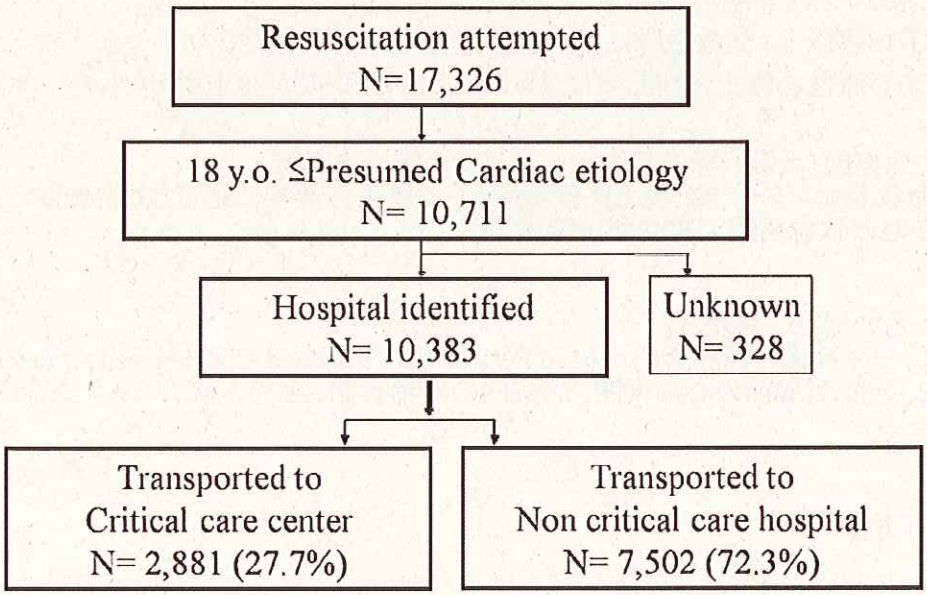
倫理的配慮
本研究は、 ヘルシンキ宣言および疫学研究に関する倫理指針を遵守して実施した。集計・解析にあたっては、 対象者特定情報は削除し、 匿名化を行った。
本プロジェクトは大阪大学医学部医学倫理委員会の承認を得ている。

【結果】

(ウツタイン大阪プロジェクトより)
対象期間に、救急隊が蘇生処置を行った18歳以上の病院外心停止のうち、心原性心停止と診断され、搬送先病院が特定された10,383例を対象とした(Fig.1)。

18 歳以上の心原性心停止症例のうち, 10,383 例は搬送先病院が特定された。

Fig.1 Cases for analysis



そのうち 2,881 例(28%)は救命救急センター(Critical care center, 以下 CCC)へ搬送され、 7,502 例(72%) はその他の救急病院(Non critical care hospital,以下 NCCH)に搬送されていた。

Table.1 All patient's characteristics

	CCC	NCCH	
	2,881	7,502	p
age (yr), mean (S.D.)	69.8 (15.7)	74.7 (14.1)	<0.001
male, n (%)	1,781 (61.8)	4,179 (55.7)	<0.001
Public location, n (%)	488 (40.2)	722 (9.6)	<0.001
Bystander CPR, n (%)	1,005 (34.9)	2,677 (35.7)	0.445
Witnessed status, n (%)			
EMS	256 (8.9)	525 (7.0)	<0.001
Bystander	1,159 (40.2)	2,343 (31.2)	<0.001
Shockable rhythm, n (%)	673 (23.4)	1,132 (15.1)	<0.001
EMS care interval (min), mean (S.D.)			
Call to EMS arrival	5.8(2.5)	6.1(2.4)	<0.001
Call to hospital arrival	27.6 (9.2)	26.1(7.5)	<0.001
Field ROSC	354 (12.3)	440 (5.9)	<0.001

CCC; Critical Care Center, NCCH; Non critical care hospital

搬送施設別患者背景を示す(Table.1)。NCCH 群の平均年齢は 74.7 ± 14.1 歳であるのに対し、CCC 群の平均年齢は 69.8 ±15.7 歳と有意に若かった (P < 0.001)。市民による虚脱(心停止)の目撃、救急隊による虚脱の目撃、男性の割合、公共場所(道路・駅など)、除細動可能な波形の割合は有意に、CCC 群で高値を示した(P < 0.001)。バイスタンダーによる CPR の割合は両群で有意差を認めなかった(P = 0.445)。覚知から救急隊到着までの時間は CCC 群 5.8 ± 2.5 分とNCCH 群 6.1 ± 2.4 分に比較して、有意に短かった (P < 0.001)。逆に覚知から病院到着までの時間は、CCC 群 27.6 ± 9.2 分とNCCH 群 26.1±7.5 分と比較して有意に長かった(P < 0.001)。

Table 2 搬送施設別の生存転帰を示す。アウトカム指標である一ヶ月後の神経学的予後良好例(CPC1 or 2)は CCC 群 6.7% (193/2881)と NCCH 群 2.8%

(213/7502)に比較して有意に高値を示した。(OR, 2.47; 95% CI, 2.02 - 3.01; P < 0.001)。

Table.1 のごとく CCC 群における病院到着前の自己心拍再開例は 354 例 (12.3%) とNCCH 群 440 例(5.9%)と比較して、有意に高値を示した (P < 0.001) 。CCC 群に

Table 2 Main Outcomes

	CCC	NCCH	
Number (%)	2,881	7,502	P
ROSC in ED	964 (33.5)	2,002 (26.7)	<0.001
Hospital admission	797 (27.7)	1,635 (21.8)	<0.001
1-month survival	333 (11.6)	402 (5.4)	<0.001
Neurologically favorable outcome (CPC 1 or 2)	193 (6.7)	213 (2.8)	<0.001

ED; Emergency Department

おける病院における心拍再開例は 964 例(34%)と NCCH 群 2002 例(27%)に比較して有意に高値を示した(P < 0.001)。CCC 群における生存入院は 797 例(28%) で NCCH 群 1635 例 (22%)に比較して有意に高値であった (P < 0.001)。一ヶ月生存についても CCC 群 333 例 (12%])と NCCH 群 402 例 (5 %]と比較して有意に高値を示した(P < 0.001)。病院到着前に自己心拍再開している症例は CCC 群例 12.3 %と NCCH 群例 5.9 %に比較して有意に高値を示しており、病院到着後の治療効果を検討する為に病院到着前の心拍再開の有無で層別解析を行った。

病院到着前に自己心拍再開が得られた症例について

CCC 群の年齢は 67.0 ± 14.8 歳と NCCH 群 69.6 ± 14.1 歳に比較して有意に若かった (P = 0.012)。CCC 群の覚知から病院到着までの時間は 30.6 ± 9.1 分と NCCH 群 27.2 ± 7.9 分に比較して有意に長かった(P < 0.001)。男性の割合、公共場所での目撃、バイスタンダーCPR の割合、バイスタンダー・救急隊による目撃の割合、除細動可能な波形の割合は 2 群間に明らかな差を認めなかった。一ヶ月後の神経学

的予後良好例の割合はCCC 群150 例[43%]とNCCH群 177例 [40.9%]と多い傾向にあったが、有意な差を認めなかった。(OR, 1.09; 95% CI, 0.82 - 1.45; P= 0.553)

(Table3-4)。

Table 3 Characteristics of field ROSC patients

	CCC	NCCH	
	354	440	p
age (yr), mean (S.D.)	67.0 (14.8)	69.6 (14.1)	0.012
male, n (%)	245 (69.2)	281 (63.9)	0.113
Public location, n (%)	84 (23.7)	102 (23.2)	0.856
Bystander CPR, n (%)	123 (34.7)	156 (35.5)	0.835
Witnessed status, n (%)			
EMS	51 (14.4)	79 (18.0)	0.179
Bystander	219 (61.9)	248 (56.4)	0.117
Shockable rhythm, n (%)	190 (53.7)	235(53.4)	0.941
EMS care interval (min), mean (S.D.)			
Call to EMS arrival	5.4(2.3)	5.5(2.2)	0.461
Call to hospital arrival	30.6 (9.1)	27.2(7.9)	<0.001

Table 4 Main Outcome of field ROSC patients

	CCC	NCCH	
Number (%)	354	440	P
Hospital admission	301 (85.0)	384 (87.3)	0.361
	0.83(0.55-1.24)	Reference	
1-month survival	203 (58.2)	245 (56.6)	0.656
	1.07 (0.80-1.42)	Reference	
Neurologically favorable outcome (CPC 1 or 2)	150 (43.0)	177 (40.9)	0.553
	1.09 (0.82-1.45)	Reference	

Table 5 Characteristics of patients without field ROSC

	CCC	NCCH	
	2,527	7,062	p
age (yr), mean (S.D.)	70.2 (15.7)	75.0 (14.0)	<0.001
male, n (%)	1,536 (60.8)	3,898 (55.2)	<0.001
Public location, n (%)	404 (16.0)	620 (8.8)	<0.001
Bystander CPR, n (%)	882 (34.9)	2,521 (35.7)	0.473
Witnessed status, n (%)			
EMS	205 (8.1)	446 (6.3)	0.002
Bystander	940 (37.2)	2,095 (29.7)	<0.001
Shockable rhythm, n (%)	483 (19.1)	897 (12.7)	<0.001
EMS care interval (min), mean (S.D.)			
Call to EMS arrival	5.8(2.5)	6.1(2.4)	<0.001
Call to hospital arrival	27.2 (9.1)	26.6(7.5)	0.005

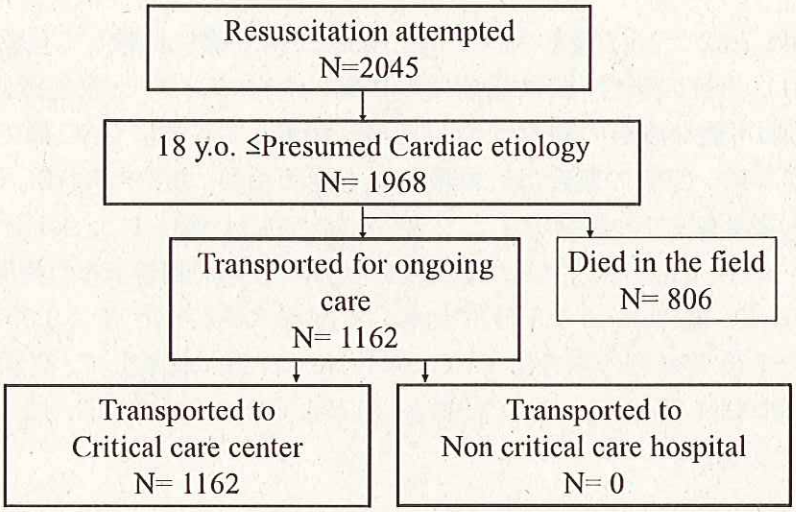
病院到着前に自己心拍再開が得られなかった症例について

CCC 群の年齢は 70.2 ±15.7 歳と NCCH 群 75.0 ± 14.0 歳に比較して有意に若かった（P ＜ 0.001)。男性の割合；公共場所での目撃、バイスタンダー・救急隊による目撃の割合、除細動可能な波形の割合はNCCH群に比較して有意にCCC群で高値を認めた。バイスタンダーCPRの割合は二群間に差を認めなかった(P = 0.473)。CCC群の覚知から救急隊到着までの時間(5.8 ± 2.5 分）はNCCH 群(6.1 ± 2.4 分)と比較して有意に短かった(P＜0.001)。しかしCCC群の覚知から病院到着までの時間（27.2 ± 9.1 分）はNCCH 群(26.6 ± 7.5 分)に比較して有意に長かった（P＜0.001)。一ヶ月後の神経学的予後良好例の割合は CCC 群が NCCH 群に比較して、有意に高値であった（CCC 群 43[1.7%] versus NCCH 群 36 [0.5%]; OR, 3.39; 95% CI, 2.17 - 5.29; P＜0.001)(Table 5-6)。

Table 6, Main Outcome without field ROSC

	CCC	NCCH	
Number (%) Unadjusted OR (95%CI)	2,527	7,062	P
ROSC in ED	639 (25.3) 1.16(1.05- 1.29)	1,593 (22.6) Reference	0.005
Hospital admission	496 (19.6) 1.13(1.01-1.27)	1,251 (17.7) Reference	0.032
1-month survival	130 (5.2) 2.39 (1.89-3.03)	157 (2.2) Reference	＜0.001
Neurologically favorable outcome (CPC 1 or 2)	43 (1.7) 3.39 (2.17-5.29)	36 (0.5) Reference	＜0.001

Cases for analysis (Portland)



これは 2005 年 12 月から 2008 年 5 月までの Portland 地域における 18 か月間のデータである。これをみると救急隊が何らかの蘇生を行った 18 歳以上の心原性心停止症例のうち 806 例(41%)は現場において、蘇生中止の判断がなされていた。また考察に後述するが、ポートランドにおいては CPA 症例の受け入れ病院がプロトコールで決定されており、全例が受け入れ病院へ搬送されていた。

次に、全症例における患者背景と生存転帰を示す。これをみるポートランドの症例は大阪の症例に比較して、年齢が若く、男性の割合が高かった。救急隊による目撃割合はポートランドのほうが大阪に比較して低値であったが、バイスタンダーによる目撃の割合、除細動可能な波形の割合は高値を示した。救急隊の活動時間を比較すると、大阪でもポートランドでも覚知から救急隊到着までの時間は概ね 5 分と変わらないが、覚知から病院到着までの時間は、ポートランドで 39.5 分と大阪に比べて、10 分以上遅かった。

All patient's characteristics and Outcome

	Osaka		Portland
	CCC:2,881	NCCH:7,502	1,968
age (yr), mean (S.D.)	69.8 (15.7)	74.7 (14.1)	64.4 (16.4)
male, n (%)	1,781 (61.8)	4,179 (55.7)	1296 (65.9)
Public location, n (%)	488 (40.2)	722 (9.6)	334 (17)
Bystander CPR, n (%)	1,005 (34.9)	2,677 (35.7)	905 (46)
Witnessed status, n (%)			
EMS	256 (8.9)	525 (7.0)	95 (4.8)
Bystander	1,159 (40.2)	2,343 (31.2)	961 (48.8)
Shockable rhythm, n (%)	673 (23.4)	1,132 (15.1)	638 (32.4)
EMS care interval (min), mean (S.D.)			
Call to EMS arrival	5.8(2.5)	6.1(2.4)	4.5 (1.5)
Call to hospital arrival	27.6 (9.2)	26.1(7.5)	39.5 (10.3)#
Field ROSC	354 (12.3)	440 (5.9)	774 (39.3)
Neurologically favorable outcome (CPC 1 or 2)*	193 (6.7)	213 (2.8)	213 (10.8)*

#Call to termination of resuscitation: 27.1 (10.2) * Survived to Discharge

次に病院到着前に自己心拍再開の有無で層別解析を行った。

Characteristics and Outcome of field ROSC pts

	Osaka		Portland
	CCC	NCCH	
	354	440	774
age (yr), mean (S.D.)	67.0 (14.8)	69.6 (14.1)	64.1 (15.8)
male, n (%)	245 (69.2)	281 (63.9)	510 (65.9)
Public location, n (%)	84 (23.7)	102 (23.2)	166 (21.4)
Bystander CPR, n (%)	123 (34.7)	156 (35.5)	346 (44.7)
Witnessed status, n (%)			
EMS	51 (14.4)	79 (18.0)	46 (5.9)
Bystander	219 (61.9)	248 (56.4)	483(62.4)
Shockable rhythm, n (%)	190 (53.7)	235(53.4)	329 (42.5)
Outcome			
Neurologically favorable outcome (CPC 1 or 2)*	150 (43.0)	177 (40.9)	197 (25.5)*

* Survived to Discharge

上記表より、病院到着前に自己心拍再開している症例を日米間で比較すると、

神経学的予後良好例は大阪では CCC,NCCH 群ともに40%を超えており、ポートランドに比較して転帰良好であることが分かった。

次に病院到着前に自己心拍再開が得られなかった症例に関して比較を行った。

Characteristics and Outcome of pts without field ROSC

	Osaka		Portland
	CCC	NCCH	
	2,527	7,062	1,193
age (yr), mean (S.D.)	70.2 (15.7)	75.0 (14.0)	64.6 (16.7)
male, n (%)	1,536 (60.8)	3,898 (55.2)	786 (65.9)
Public location, n (%)	404 (16.0)	620 (8.8)	168 (14.1)
Bystander CPR, n (%)	882 (34.9)	2,521 (35.7)	559 (46.9)
Witnessed status, n (%)			
EMS	205 (8.1)	446 (6.3)	49 (4.1)
Bystander	940 (37.2)	2,095 (29.7)	478 (40.1)
Shockable rhythm, n (%)	483 (19.1)	897 (12.7)	309 (25.9)
Outcome			
Neurologically favorable outcome (CPC 1 or 2)*	43 (1.7)	36 (0.5)	16 (1.3)*

* Survived to Discharge

神経学的予後良好例の割合を比較すると大阪のCCC群とPortlandの値は、それぞれ1.7%,1.3%と同等であった。

【考察】

本研究は、大阪府下という population based での病院外心停止症例に対する搬送先病院の影響の差を検討した初めての報告である。仮定どおり、救命救急センター搬送例はその他の救急病院に搬送された症例に比較して、有意に生存転帰を改善していた。救命救急センターへの搬送は、特に病院前に心拍再開し得なかった症例に対して良好な転帰を与える可能性が示唆された。Herliz らの報告では(7)、病院前で蘇生され心拍再開状態で搬送された心原性院外心停止例のうち、一か月生存した症例を検討したところ、病院到着前の予後規定因子を調整した後も、生存率上位 3 病院は下位 3 病院と比較して 2. 3 倍良好であり、搬送先病院が予後良好因子となっていたと報告している。また同様に Hollenberg ら(8)は、同一都市で同一 EMS が搬送した 2 つの病院の検討を報告しているが、これにおいても、総合的な病院到着後の治療が生存退院に影響しているとしている。我々の研究においても、蘇生治療に特化した施設に搬送された例は、他の救急病院に搬送された例に比較して、有意に良好な転帰を得ていた。

ポートランドとの比較結果を考察する前に、同地域の病院前救護体制について説

明する。まず CPA 症例の受け入れ病院についてであるが大阪とは異なり、Oregon Health & Science Univ. Hospital や Legacy - Emmanuel Hospital といった Emergency Department（救急部）を有する地域の基幹病院 17施設が CPA 症例受け入れ病院として決まっており、その他の医療機関には行かない仕組みになっている。EMS システムは日本と同様、地域の Fire & Rescue が出動する形態をとっており Paramedic が在籍しているが、自前の救急車は持たず、消防車で出動する。救急車は通報と同時に Paramedic の資格をもつ民間救急車が現場に駆け付けることになっており、現場では消防側の Paramedic と民間救急車側の Paramedic が共同して治療に当たっている。もっとも我が国と異なるところは、救急隊（EMS）が行う病院前救護の医療責任者として地域の救急医が County Medical Director や Fire Department Medical Director に任命されているところである。彼らは救急隊（EMS）による病院前救護の質の評価、医療教育を行うだけではなく、地域における病院前救護の治療指針（Patient Treatment Protocol）を年次的に改変・更新する権限を持っていると同時に、EMS の医療活動に対する責任をおっていた。同地域においてはプロトコールで VF/VT がつづく症例は全例搬送適応となるが、PEA・心静止の患者では、適切にパラメディックが BLS、ALS を行い、蘇生できなかった症例はオンラインメディカルコントロール下で、現場で死亡宣告をすることができる。現にポートランドでは救急隊が蘇生に関与した症例の 40% は現場で蘇生中止（死亡宣告）となっていた。現場での死亡確認が認められているため（救急隊到着から死亡確認までの時間：平均時間 27.1 分）、ポートランドと大阪を比較すると、ポートランドでの現場滞在時間が大阪に比べ長いと考えられた。全対象症例の生存転帰を比較すると、大阪に比較してポートランドの病院前心拍再開率、神経学的予後良好例が高いことが分かった。これはポートランドにおいてはバイスタンダーによるCPR施行率が高く、また病院前救護として救命士による ALS が認められている為、現場で心室細動を維持するまた二次的に心室細動に移行出来た症例が多く、これが神経学的予後に影響していると考えられた。病院到着前に自己心拍再開した症例を比較すると、ポートランドに比較して大阪の神経学的予後良好例の割合が高値を示した。これは大阪においては救急隊到着時に心室細動で BLS のみで自己心拍再開している症例が多く、逆にポートランドでは現場で長時間ALSを行って、自己心拍再開に至った症例が多いことが原因と考えられた。今回システムの違いから、米国のデータからは搬送施設別の転帰の差を検討できなかったが、ウツタイン様式という共通のデータ集積・解析方法を使うことにより、比較検討することができた。

（最後に）

今回我々の研究から、「救命センターへの搬送」は良好な転帰を得る為の要因の一つになっていた。病院到着前に心拍再開が得られた症例に関しては、救命センター搬送群、非搬送群で有意な差は認められなかった。病院到着前に心拍再開が

得られなかった症例では、より救命センター搬送群で良好な転帰が得られていた。本研究では救命センターの何が転帰良好な要因(治療内容？マンパワー？)として影響しているかについては、明らかに出来なかった。転帰良好因子については今後もさらなる検討が必要と思われる。 またポートランドのデータと比較することにより、大阪の現状を客観的に評価することが可能であった。欧米では、蘇生率の低さから、救命士が適切な処置を行っても自己心拍再開に至らない症例に関しては、蘇生中止を考慮すべきとしている(11)。早急な病院外心停止症例の生存転帰に基づく搬送施設選定基準の作成は言うまでもないが、救命士の処置を拡大するとともに、オンラインメディカルコントロール下での蘇生中止(死亡宣告)についても、検討が必要と思われる。

この研究は、(財)救急振興財団の「救急に関する調査研究事業助成」を受けて行ったものである。

【参考資料】

1、ウツタイン大阪プロジェクト 病院外心肺停止患者登録コード一覧

2、参考文献

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病院外心肺停止患者記録(大阪版) コード表

No.	項目名	コード
1	本部コード	
2	救急隊コード	
3	発生年	発生年月日の年
4	事例No	
5	プロトコールA	0:なし、1:あり
6	プロトコールB	0:なし、1:あり
7	プロトコールC	0:なし、1:あり
8	プロトコールD	0:なし、1:あり
9	プロトコールE	0:なし、1:あり
10	プロトコールF	0:なし、1:あり
11	発生年月日	YYYYMMDD
12	救急救命士乗車	1:気管挿管認定救命士が乗車 2:薬剤投与認定救命士が乗車 3:気管挿管・薬剤投与認定救命士ともに乗車 4:上記以外の救急救命士が乗車 5:救急救命士乗車なし
13	ドクターカー出場	0:なし、1:現場、2:ドッキング、3:両方
14	医師同乗	N:未選択、0:なし、1:あり
15	患者性別	1:男、2:女
16	患者年齢	
17	患者年齢推定区分	N:未選択、1:推定
18	初期治療病院名	
19	心疾患の既往症	1:あり、2:なし、3不明
20	心疾患の既往症内訳 虚血性心疾患(狭心症・心筋梗塞)	0:なし、1:あり
21	心疾患の既往症内訳 ペースメーカー植込み	0:なし、1:あり
22	心疾患の既往症内訳 その他	0:なし、1:あり
23	普段の生活状態	1:良好 2:中等度障害(片麻痺、構語障害等)あるも自立 3:重度障害あり要介助(ねたきり) 4:植物状態 5:不明
24	現場での傷病判断	1:内因性、2:外因性
25	現場での傷病判断内訳	N:未選択 1:前駆症状あり 2:前駆症状なし 3:不明
26	心肺停止の目撃	1:心肺停止の瞬間を目撃、または音を聞いた 2:既に心肺停止(心肺停止の状態で発見)
27	心肺停止の時分	mmss 例)8時7分 → 0807
28	心肺停止の目撃者	N:心肺停止の目撃=2の場合 1:家族 2:その他(友人) 3:その他(同僚) 4:その他(通行人) 5:その他(その他) 6:消防隊員 7:救急隊員 8:救急救命士隊

29	心肺停止場所	1:家 2:道路上 3:職場 4:公衆の出入りする場所 5:救急車内 6:医院内 7:老人ホーム 8:学校 9:その他
30	心肺停止場所公衆内訳	N:心肺停止場所≠4の場合 1:公的施設 2:鉄道駅 3:空港 4:スポーツ施設 5:その他
31	心肺停止場所その他備考欄	心肺停止場所＝9の場合 必須
32	心肺停止時の状況	1:運動中 2:入浴中 3:就労中 4:就寝中 5:その他 6:不明
33	口頭指導	0:なし、1:あり
34	口頭指導内訳	N:口頭指導＝0の場合 1:人工呼吸のみ 2:心臓マッサージのみ 3:人工呼吸と心臓マッサージ
35	バイスタンダーCPR	0:なし、1:あり
36	バイスタンダーCPR内訳	N:バイスタンダーCPR＝0の場合 1:人工呼吸のみ 2:心臓マッサージのみ 3:人工呼吸と心臓マッサージ
37	バイスタンダーCPR開始時刻	mmss 例)8時7分 → 0807
38	バイスタンダーCPR開始時刻区分	1:確定、2:推定、3:不明、4:バイスタンダーCPR＝0の場合
39	市民等による除細動	0:なし、1:あり
40	市民等による除細動開始時刻	mmss 例)8時7分 → 0807
41	市民等による除細動開始時刻区分	1:確定、2:推定、3:不明、4:市民等による除細動＝0の場合
42	市民等による除細動実施者	N:市民等による除細動＝0 0:医療従事者 1:非医療従事者 2:不明
43	市民等による除細動 除細動実施者AED講習会受講暦の有無	N:市民等による除細動＝0 1:あり 2:なし 3:不明
44	時間経過1(覚知から患者接触まで) 覚知時刻	mmss 例)8時7分 → 0807
45	時間経過1(覚知から患者接触まで) 出場時刻	mmss 例)8時7分 → 0807
46	時間経過1(覚知から患者接触まで) 現場到着時刻	mmss 例)8時7分 → 0807
47	時間経過1(覚知から患者接触まで) 患者接触時刻	mmss 例)8時7分 → 0807
48	救急隊到着時の状態	1:心肺停止 2:心機能のみ停止 3:呼吸機能のみ停止 4:心・呼吸機能ともあり
49	救急隊員によるCPR	1:施行 2:施行せず 3:人工呼吸のみ
50	救急隊員によるCPR開始時間	mmss 例)8時7分 → 0807
51	救急隊到着時の医師による2次救命処置	0:なし、1:あり

52	初期心電図波形	1:心室細動 2:無脈性心室頻拍 3:無脈性電気活動(PEA) 4:心静止 5:その他 6:装着できず
53	初期心電図波形その他備考欄	初期心電図波形＝5の場合　必須
54	初期心電図波形モニター装着時刻	初期心電図波形≠6の場合 必須 mmss　例)8時7分　→　0807
55	除細動	0:実施せず 1:実施
56	除細動実施	0:除細動＝0の場合 1:二相性 2:単相性
57	除細動実施者 救急救命士	N:除細動＝0の場合 0:実施せず 1:実施
58	除細動実施者 救急隊員	N:除細動＝0の場合 0:実施せず 1:実施
59	除細動実施者 消防隊員	N:除細動＝0の場合 0:実施せず 1:実施
60	除細動実施者 その他	N:除細動＝0の場合 0:実施せず 1:実施
61	除細動施行回数	除細動＝1の場合有効
62	除細動適応波形確認時刻	除細動＝1の場合　必須 mmss　例)8時7分　→　0807
63	初回除細動実施時刻	除細動＝1の場合　必須 mmss　例)8時7分　→　0807
64	特定行為気道確保	0:実施せず 1:実施
65	特定行為気道確保実施区分	0:特定行為気道確保＝0の場合 1:LM 2:食道閉鎖式エアウェイ 3:挿管チューブ
66	食道閉鎖式エアウェイ	0:特定行為気道確保＝0 and 特定行為気道確保実施区分 ≠ 2 の場合 1:スミウェイ 2:コンビチューブ 3:ラリンゲアルチューブ 4:その他
67	最終気道確保器具挿入時刻	特定行為気道確保＝1の場合　必須 mmss　例)8時7分　→　0807
68	静脈路確保	0:施行 1:施行せず 2:施行できず
69	薬剤投与	0:実施せず 1:実施
70	薬剤投与回数	
71	薬剤投与時刻	薬剤投与＝1の場合　必須 mmss　例)8時7分　→　0807
72	時間経過2(搬送開始から病院到着まで) 搬送開始時刻	mmss　例)8時7分　→　0807
73	時間経過2(搬送開始から病院到着まで) 病院到着時刻	mmss　例)8時7分　→　0807
74	病院到着前の心拍再開	1:あり 2:なし
75	初回心拍再開時刻	mmss　例)8時7分　→　0807
76	病院到着時患者状況 脈拍	1:あり 2:なし

77	病院到着時患者状況 呼吸	1:あり 2:なし
78	病院到着時心電図	1:心室細動 2:心室頻拍 3:心静止 4:無脈性電気活動 5:その他
79	病院到着時心電図その他備考	
80	二次救命処置	0:施行 1:施行せず
81	二次救命処置未施行理由	N:二次救命処置＝0の場合 1:医学的社会的理由 2:全身状態改善
82	CPAに至った原因	1:心原性 2:非心原性
83	CPAに至った原因心原性内訳	N:CPAに至った原因＝2の場合 1:確定(疑い含む) 2:除外診断
84	CPAに至った原因非心原性内訳	N:CPAに至った原因＝1の場合 1:脳血管障害 2:呼吸器 3:悪性腫瘍 4:外因性 5:その他
85	CPAに至った原因非心原性 外因性内訳	N:CPAに至った原因非心原性内訳≠4の場合 1:交通事故 2:墜落・転落 3:縊首 4:溺水 5:窒息 6:中毒 7:不明
86	CPAに至った原因非心原性 外因性内訳 窒息理由	0:餅以外　or CPAに至った原因非心原性外因性内訳≠5の場合 1:餅
87	CPAに至った原因非心原性その他備考	CPAに至った原因非心原性内訳＝5の場合　必須
88	病院到着後心拍再開	0:あり 1:なし 2:病院到着時既に心拍再開
89	搬入後心拍再開時刻	mmss　例)8時7分　→　0807
90	病院搬入後の状態	0:ICU／病棟入院 1:外来処置室で死亡
91	発症1ヶ月予後の回答	1:あり 2:なし 3:回答待ち
92	発症1ヶ月後生存	1:あり 2:なし 3:回答待ち
93	発症1ヶ月後生存あり内訳	N:発症1ヶ月後生存≠1の場合 1:入院中 2:生存退院
94	発症1ヶ月後生存なし 死亡年月日	発症1ヶ月後生存＝2の場合　必須 YYYYMMDD
95	発症1ヶ月後または退院時の機能評価 全身機能評価	0:発症1ヶ月後生存＝3の場合 1:良好 2:中等度障害あるも自立 3:重度障害あり要介助 4:植物状態 5:死亡又は脳死 or 病院到着後心拍再開＝1の場合

96	発症1ヶ月後または退院時の機能評価 脳機能評価	0:発症1ヶ月後生存＝3の場合 1:良好 2:中等度障害あるも自立 3:重度障害あり要介助 4:植物状態 5:死亡又は脳死 or 病院到着後心拍再開＝1の場合
97	発症1年後生存	N:発症1ヶ月後生存≠1の場合 1:あり 2:なし
98	発症1年後生存あり内訳	N:発症1年後生存≠1の場合 1:入院中 2:生存退院
99	発症1年後生存なし 死亡年月日	発症1年後生存＝2の場合　必須 YYYYMMDD
100	発症1年後の機能評価 全身機能評価	0:発症1ヶ月後生存＝3の場合 1:良好 2:中等度障害あるも自立 3:重度障害あり要介助 4:植物状態 5:死亡又は脳死 or 病院到着後心拍再開＝1の場合
101	発症1年後の機能評価 脳機能評価	0:発症1ヶ月後生存＝3の場合 1:良好 2:中等度障害あるも自立 3:重度障害あり要介助 4:植物状態 5:死亡又は脳死 or 病院到着後心拍再開＝1の場合
102	メモ	
103	登録状態	0:仮登録、1:本登録
104	削除フラグ	0:有効、1:削除

※　各項目は可変長のカンマ区切りとなります。また、1件分のデータは改行コードを終端記号としてください。
　　（各項目はダブルクォーテーションで囲む必要はありません）
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CLINICAL PAPER

Major differences in 1-month survival between hospitals in Sweden among initial survivors of out-of-hospital cardiac arrest☆

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KEYWORDS
Cardiac arrest;
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Summary
Aim: To explore the rate of survival to hospital discharge among patients who were brought to hospital alive after an out-of-hospital cardiac arrest in different hospitals in Sweden.
Patients and methods: All patients who had suffered an out-of-hospital cardiac arrest which was not witnessed by the ambulance crew, in whom cardiopulmonary resuscitation (CPR) was started and who had a palpable pulse on admission to hospital were evaluated for inclusion. Each participating ambulance organisation and its corresponding hospital(s) required at least 50 patients fulfilling these criteria.
Results: Three thousand eight hundred and fifty three patients who were brought to hospital by 21 different ambulance organisations fulfilled the inclusion criteria. The number of patients rescued by each ambulance organisation varied between 55 and 900. The survival rate, defined as alive 1 month after cardiac arrest, varied from 14% to 42%. When correcting for dissimilarities in characteristics and factors of the resuscitation, the adjusted odds ratio for survival to 1 month among patients brought to hospital alive in the three ambulance organisations with the highest survival versus the three with the lowest survival was 2.63 (95% CI: 1.77–3.88).
Conclusion: There is a marked variability between hospitals in the rate of 1-month survival among patients who were alive on hospital admission after an out-of-hospital cardiac arrest. One possible contributory factor is the standard of post-resuscitation care.

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Introduction

Among patients who suffer an out-of-hospital cardiac arrest, overall survival to discharge or at one month is low.[1] To improve outcome, the "chain of survival" concept has emerged. It includes (1) early recognition and call for the emergency medical service (EMS); (2) early cardiopulmonary resuscitation (CPR); (3) early defibrillation; (4) early advanced cardiac life support (ALS).

In recent years, evidence indicates that we should introduce a fifth link into the chain of survival, i.e. post-resuscitation care. Until now, there are no clear recommendations about how survivors should be treated in the initial phase after cardiac arrest. Therefore the level of treatment may vary between hospitals and affect the outcome.

This survey aims to explore differences in survival between various hospitals in Sweden among patients who were brought to hospital alive after having suffered an out-of-hospital cardiac arrest.

Patients and methods

Patients

Patients suffering a cardiac arrest for whom the ambulance was called were included in the registry. Cases of arrest witnessed by the ambulance crew and patients in whom CPR was inappropriate or who had obviously been dead for a long time, and were not taken to hospital, were excluded. For the others, the standardised form was completed by the ambulance crew.

Registry

This study is based on material collected by the Swedish Cardiac Arrest Registry, which is a joint venture between the Federation of Leaders in Swedish Ambulance and emergency services (FLISA) and the working group on CPR within the Swedish Society of Cardiology. Since 1993, the registry has been funded by the Swedish National Board of Health and Welfare. The registry, which is voluntary, started in 1990 with a few ambulance services. It has been successively joined by others and 57 ambulance services were involved in the registry during the time of the survey.

Study design

For each case the ambulance crew (mostly two persons, one of whom is usually a nurse) filled in a form with information such as age, place of arrest, probable background to the arrest, bystander occupation and a standardised description of the resuscitation procedure, including intervention times and interventions such as bystander CPR (a bystander was defined as someone starting CPR before the arrival of the first ambulance, regardless of profession), defibrillation, intubation, drug treatment and status at the first contact.

In ambulances with manual defibrillators, the rhythm was defined as ventricular fibrillation, pulseless electrical activity or asystole. For automated external defibrillators, the rhythm was defined as shockable, or non-shockable. In this study, ventricular fibrillation includes patients with pulseless ventricular tachycardia.

Professionals included health care professionals (ambulance personnel were also included but not the crew of the arriving ambulance). The remaining bystanders were defined as lay persons who also included policemen. To establish the time of cardiac arrest in witnessed cases, the ambulance crew was instructed to interview the bystanders about the delay from arrest to the ambulance call. The ambulance crew also classified the aetiology of the arrest in nine different diagnostic categories (heart disease, lung disease, trauma, drug overdose, suicide, drowning, suffocation, sudden infant death syndrome and "other") based on clinical assessment and bystander information. Their diagnosis was accepted for this study and no further control was made among initial survivors during hospitalisation. The form was completed during and immediately after the acute event. Each form was sent to the medical director with a copy to the central registry in Göteborg. Another copy was subsequently sent with additional information about whether the patient was dead or alive after 1 month. If there was uncertainty about survival, this was checked according to the National Registry of Deaths. All data were computerised in a database in Göteborg.

No absolute validation of adherence to the protocol was performed. Instead, a questionnaire was sent to all the medical directors of the ambulance organisations participating in the registry. They were asked to estimate the accuracy of the representation of the study population. They estimated the percentage of the study population that was wrongly omitted from the study in their own district. Percentage values from this survey varied from 0% to 30% (mean 5%).

Inclusion criterion

The inclusion criterion in this study was patients who were admitted to hospital alive. This was

Table 1 A comparison between patients from the three corresponding hospitals with the highest survival with patients from the three corresponding hospitals with the lowest survival

	Highest (n=237)	Lowest (n=1105)	p**
Age (years, mean ± S.D.) (39)[a]	68 ± 15	69 ± 15	
Sex (%)			
Male	73	62	0.002
Aetiology (%) (87)			
Cardiac	78	62	<0.0001
Initial rhythm (%) (155)			
Ventricular fibrillation	65	45	<0.0001
Bystander witnessed (%) (129)	82	77	
Bystander CPR (%) (58)	45	43	
Interval (median, min)			
Call for ambulance–arrival of ambulance (61)	4	6	
Start of transport to hospital–arrival in hospital (181)	10	7	<0.0001

[a] Number of patients with missing information (of all 1342 patients).
** p-Value denoted if <0.05.

defined as patients with a palpable pulse on admission to hospital. This is in line with the Utstein criteria.[2]

Statistical methods

Ambulance organisations that brought at least 50 patients to hospital with a palpable pulse on hospital admission were included in the analysis. Each ambulance organisation brought these patients to a single hospital, with the exception of the two largest communities (Stockholm and Göteborg), where the ambulances brought the patients to seven and two hospitals respectively. In the analysis, the seven and two hospitals were counted as one each, as we had no detailed information for each of the seven hospitals in Stockholm.

Descriptive statistics

The distribution of variables is given as a percentage, mean ± standard deviation and median.

Statistical analyses

For comparisons between groups in terms of continuous variables, Fisher's non-parametric permutation test was used. For comparisons of dichotomous variables between the two groups, Fisher's exact test was used. A p-value of less than 0.05 was regarded as significant. Two-tailed tests were applied.

Multivariate statistical analyses

A stepwise logistic regression was used to select independent predictors of dichotomous dependent variables, i.e. alive 1 month after cardiac arrest. For all patients, as well as for patients suffering a bystander-witnessed cardiac arrest with cardiac aetiology, an adjusted odds ratio was thereby calculated for survival in the three corresponding hospitals with the highest survival versus the three corresponding hospitals with the lowest survival. Further variables entered into the model were those that differed between high- and low-risk hospitals according to Tables 1 and 2 ($p < 0.05$). Variables entered into the model were sex, aetiology (cardiac versus non-cardiac), initial rhythm (ventricular fibrillation versus no ventricular fibrillation) and transport time to hospital (a continuous variable). For patients with a bystander-witnessed cardiac arrest, these variables were age (continuous variable) and sex.

Results

Thirty one thousand one hundred and twenty seven patients suffered an out-of-hospital cardiac arrest in whom CPR was attempted and which were not witnessed by the ambulance crew. Of these, 4667 were brought to hospital with a palpable pulse on hospital admission. Since only hospitals with an ambulance organisation from which at least 50 patients were admitted to hospital alive have

Table 2 A comparison of patients with a bystander witnessed cardiac arrest with a cardiac aetiology from the three corresponding hospitals with the highest survival with those from the three corresponding hospitals with the lowest survival

	Highest (n=269)	Lowest (n=538)	p**
Age (years, mean ± S.D.) (12)[a]	68 ± 14	72 ± 11	<0.0001
Sex (%) (24)			
Male	76	65	0.002
Initial rhythm (%) (78)			
Ventricular fibrillation	68	63	
Bystander CPR (%) (18)	53	52	
Interval (median, min)			
Cardiac arrest–call for ambulance (147)	2	3	
Cardiac arrest–arrival of ambulance (126)	7	9	
Start of transport to hospital–arrival in hospital (94)	5	8	

[a] Number of patients with missing information (of all 807 patients).
** p-Value denoted if <0.05.

been included, this means that hospitals to which patients were brought alive by 21 different ambulance organisations, comprising 38% of all 56 participating ambulance organisations, took part. The evaluated patients (n = 3853) correspond to 83% of all the patients brought to hospital alive.

All patients

Figure 1 shows the percentage of survivors at 1 month in each hospital; this figure varied from 14% to 42%.

Table 1 lists the patients from the hospitals corresponding to the three ambulance organisations with the highest survival rate (mean 38%) compared with the patients from the three corresponding hospitals with the lowest survival rate (mean 15%).

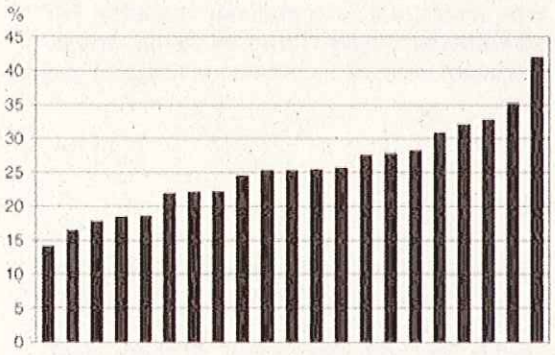

Figure 1 Survival to 1 month in 21 corresponding hospitals among all patients who were alive on hospital admission after out-of-hospital cardiac arrest (crew-witnessed cases not included).

From the table it can be seen that patients in hospitals with the highest survival rate differed from those with the lowest survival rate in that there was a higher percentage of men, a cardiac aetiology, ventricular fibrillation and a longer transport time to hospital.

Patients with a bystander-witnessed cardiac arrest with a cardiac aetiology

Only hospitals corresponding to ambulance organisations where at least 50 patients fulfilled the criteria and were brought to hospital with a pulse-generating rhythm on admission to the emergency department were included in the registry. As a result, the survival rate varied between 18% and 46% and only hospitals corresponding to 12 ambulance organisations were included in the analysis (Figure 2).

Patients from the hospitals with the highest survival differed from those with the lowest survival by being younger and including more men (Table 2). Otherwise, no significant difference was seen.

Adjusted survival rate

All patients

When adjusting for the difference in baseline characteristics, i.e. sex, aetiology, occurrence of ventricular fibrillation and transport to hospital time, the odds ratio and 95% confidence limit for being alive at 1 month in the hospitals corresponding to

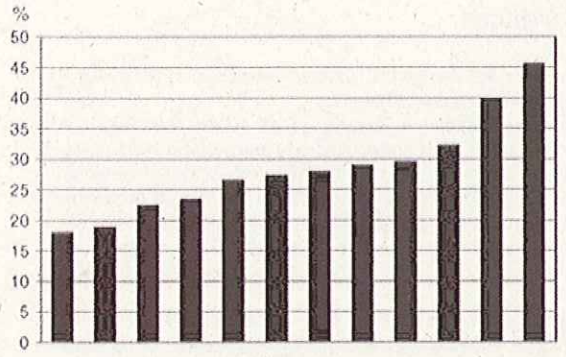

Figure 2 Survival to 1 month in 12 corresponding hospitals among patients with a bystander-witnessed cardiac arrest with a cardiac aetiology who were alive on hospital admission after out-of-hospital cardiac arrest.

the three ambulance organisations with the highest survival rate versus the three hospitals with the lowest survival was 2.63 (1.77–3.88). Due to missing information on the variables that were adjusted for, these data were based on 66% of available patients.

Patients with a bystander-witnessed cardiac arrest with a cardiac etiology

When adjusting for the difference at baseline, i.e. age and sex, the odds ratio for being alive at 1 month was 2.49 (1.77–3.51) if the three corresponding hospitals with the highest survival were compared with the three with the lowest survival. Due to missing information on the variables adjusted for these data were based on 93% of available patients.

Larger versus smaller communities

When the three largest communities, Stockholm, Göteborg and Malmö, which are the three largest communities in Sweden, were compared with the remaining communities, survival to 1 month was 19% versus 26% ($p < 0.0001$).

Discussion

In this survey comprising hospitals corresponding to 21 ambulance organisations in Sweden participating in the Swedish Cardiac Arrest Registry, we describe the variation in survival to 1 month among patients who were brought to hospital alive after having suffered an out-of-hospital cardiac arrest. The survival rate varied between 14% and 42%, i.e. there was a three-fold increase in survival in the most successful hospitals compared with the least successful. There are a variety of possible explanations for our observations.

Firstly, patients differed markedly in terms of characteristics and in various factors at the resuscitation event when different hospitals were compared. For example, more males were found in the hospitals with a higher survival rate. Furthermore, in these hospitals, patients appeared to be younger and ventricular fibrillation appeared to be more frequent as the initial rhythm. Finally, it was surprising to find that the transport time was longer to these hospitals.

However, when correcting for these discrepancies, there is still a difference between hospitals in terms of survival.

The most plausible explanation for this difference is variability in the level of post-resuscitation treatment provision between hospitals. Since this information was not available, it remains a matter of speculation.

However, this hypothesis is supported by previous experience. Engdahl et al.[3] reported a difference in survival rate between two hospitals receiving survivors after out-of-hospital cardiac arrest from the same EMS system. At the same time, they also found differences in the use of various post-resuscitation treatments between the two hospitals. They were not, however, able to prove that these differences in treatment regimes explained the difference in survival.

Langhelle et al.[4] also found a difference in survival to discharge from hospital when comparing initial survivors after out-of-hospital cardiac arrest in four hospitals in Norway. In this survey, four different predictors of a worsening outcome were described, i.e. a high body temperature, elevation of blood glucose, acidosis and seizures. However, the authors were not able to demonstrate a major difference in any of these risk factors that could explain the difference in survival.

The observation that survival was higher in smaller than larger communities is important. We have no clear explanation for this finding.

Limitations

There are number of limitations to this survey.

(1) Information is missing for a number of patients for each variable. We cannot exclude the possibility that the number of patients with missing information have influenced the interpretation of data, particularly with regard to the first multivariate analysis. In the analysis of bystander witnessed cases of a cardiac aetiology only 7% had missing information on all

variables and here the interpretation of data was probably not markedly influenced by missing information.

(2) We cannot exclude the possibility of a difference in neurological and cardiovascular function on admission to hospital between hospitals which might have influenced outcome. This is the most disturbing limitation, since we know that neurological status on admission to hospital will influence outcome substantially.[5–7]

(3) We have no information about the post-resuscitation care in the different hospitals, i.e. how patients were actually treated.

(4) The information on presumed cardiac aetiology was based upon the initial assessment by the ambulance crew. We cannot exclude some errors here.

Conclusion

In a Swedish survey of initial survivors of out-of-hospital cardiac arrest, the percentage of patients who survived to 1 month varied between 14% and 42%. This could be explained to some extent by a difference in patient characteristics and factors at resuscitation. However, differences in post-resuscitation care between hospitals cannot be ruled out as a contributory factor.

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An evaluation of post-resuscitation care as a possible explanation of a difference in survival after out-of-hospital cardiac arrest☆

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KEYWORDS
Out-of-hospital cardiac arrest;
Sudden cardiac death;
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Ventricular fibrillation;
Cardiopulmonary resuscitation (CPR)

Summary
Background: A recently published study has shown that survival after out-of-hospital cardiac arrest (OHCA) in Göteborg is almost three times higher than in Stockholm. The aim of this study was to investigate whether in-hospital factors were associated with outcome in terms of survival.
Methods: All patients suffering from OHCA in Stockholm and Göteborg between January 1, 2000 and June 30, 2002 were included. The two groups were compared with reference to patient characteristics, medical history, pre-hospital and hospital course (including in-hospital investigations and interventions) and mortality. All medical charts from patients admitted alive to the different hospitals were studied. Data from the Swedish National Register of Deaths regarding long-term survival were analysed. Pre-hospital data were collected from the Swedish Ambulance Cardiac Arrest Register.
Results: In all, 1542 OHCA in Stockholm and 546 in Göteborg were registered during the 30-month study period. In Göteborg, 28% (153 patients) were admitted alive to the two major hospitals whereas in Stockholm 16% (253 patients) were admitted alive to the seven major hospitals ($p < 0.0001$). On admission to the emergency rooms, a larger proportion of patients in Stockholm was unconscious ($p = 0.006$), received assisted breathing ($p = 0.008$) and ongoing CPR ($p = 0.0002$). Patient demography, medical history, in-hospital investigations and interventions and in-hospital mortality (78% in Göteborg, 80% in Stockholm) did not differ between the two groups.

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Various pre-hospital time intervals were significantly longer in Stockholm than in Göteborg. Total survival to discharge after OHCA was 3.3% in Stockholm and 6.1% in Göteborg ($p=0.01$).

Conclusion: An almost 2-fold difference in survival after OHCA between Stockholm and Göteborg appears to be associated with pre-hospital factors only (predominately in form of prolonged intervals in Stockholm), rather than with in-hospital factors or patient characteristics.

1. Introduction

Death from cardiac disease is the single most common cause of mortality in the western world and the majority of these deaths occurs out-of-hospital.[1] The vast majority of studies made so far on out-of-hospital cardiac arrests (OHCA) have focused primarily on features related to Emergency Medical Services (EMS), including the four links of the "chain-of-survival" concept, i.e., early access, early CPR, early defibrillation and early advanced life support.[2] Some of these factors, predominately early CPR and early defibrillation, have been associated with increased survival rates.[3–5] However, during the last few years questions about the in-hospital phase have also been raised. Following the publication of two randomised, controlled studies that demonstrated improved neurological outcome in comatose survivors after ventricular fibrillation,[6,7] therapeutic mild hypothermia is becoming implemented in clinical practice. This has led to the proposition of an additional fifth link to the "chain-of-survival" concept called post-resuscitation care. However, the effects of post-resuscitation care on survival after OHCA are still poorly recognised and are sparse.

A recent study in Sweden[8] has shown that survival after OHCA in Göteborg is almost three times higher than in Stockholm and the proportion of patients with shockable rhythms is much lower in Stockholm compared with Göteborg. This is probably due to the longer intervals in Stockholm from the time of the cardiac arrest to critical resuscitation. The aim of this study was to explore whether there were differences also in in-hospital investigations and interventions between the two largest cities in Sweden, Stockholm and Göteborg, and to study possible mechanisms behind such differences. We therefore wanted to investigate whether in-hospital factors were associated with outcome in terms of survival or whether the difference in survival is due to pre-hospital factors only.

2. Methods and patients

2.1. Organisation and equipment

The ambulance organisations in Stockholm and Göteborg work according to a two-tier system, i.e. for each call judged as a cardiac arrest, a mobile coronary care unit (if available), and an ambulance, are dispatched. Ambulances usually did not carry nurses but were equipped with specialised ambulance personnel trained in basic CPR and the use of defibrillators. The educational programme for the ambulance personnel is the same in both cities. The mobile coronary care units in both cities are equipped with a registered nurse trained in anaesthesiology with additional courses in advanced cardiac life support. Both mobile coronary care units and ambulances are equipped with defibrillators. The ambulances are stationed throughout the two cities and are not predominantly situated at the hospitals. The pre-hospital (ambulance) pharmacological treatment does not differ between Göteborg and Stockholm nor from that given in other parts of Sweden. Further details on organisation, equipment and crew training levels are described elsewhere.[8] All ambulance organisations have physicians as medical directors.

There are seven major hospitals in the County of Stockholm and two major hospitals in Göteborg. They are situated predominately within the city centers and in larger suburbs, and are geographically spread in densely populated areas.

At the time of this study, hypothermia as treatment after OHCA had not been introduced in Göteborg or Stockholm.

2.2. Study design

In order to achieve the aim of this study, two groups of patients suffering OHCA were studied. One group consisted of patients resuscitated after OHCA in the city of Göteborg and the other group comprised patients resuscitated after OHCA in the county of Stockholm. As described above, the EMS systems

in both cities work in an almost identical manner. Our purpose was to study patient characteristics, in-hospital investigations and interventions and mortality. Medical history, pre-hospital and hospital course were studied. All medical charts from patients admitted alive to the different hospitals were studied by Hollenberg and co-workers. Moreover, death certificates, laboratory results and ECGs were studied and if there was uncertainty about survival, confirmation was obtained from the Swedish National Register of Deaths. For the pre-hospital phase, data were collected from the Swedish Ambulance Cardiac Arrest Register which contains data from the specific reports completed after every OHCA. The ambulance crews in Stockholm and Göteborg filled in the same forms with relevant information such as age, place of arrest, bystander CPR, witnesses, resuscitation procedure, probable cause of arrest, intervention times, defibrillation, intubation, drug treatment, type of initial rhythm and clinical findings at first contact. To estimate the time of cardiac arrest in witnessed cases, the ambulance crews were instructed to interview the bystanders about the delay from arrest to call. It was stressed in written instructions that a maximum effort had to be made to obtain these times. The Swedish Ambulance Cardiac Arrest Register has been described in detail elsewhere.[8]

This study was approved by the local ethics committee.

2.3. Patients

2.3.1. Target populations

On December 31, 2000 the municipality of Göteborg had a population of 466,990 inhabitants with a population density of 1036 inhabitants/km^2 compared with a population of 1,823,210 inhabitants with a population density of 280 inhabitants/km^2 in Stockholm.

The two cities are the largest in Sweden. The proportion of men in both Stockholm and Göteborg is 49%. The mortality per 100,000 inhabitants in ischaemic heart disease and acute myocardial infarction during 2000–2001 was slightly higher in Göteborg compared with Stockholm 215 versus 170 and 120 versus 98, respectively.[9]

2.3.2. Patients included

All cases of OHCA in Stockholm and Göteborg where any type of resuscitation measure (airway assistance, chest compressions, administration of drugs, intubation and defibrillation) was used between January 1, 2000 and June 30, 2002 were included, regardless of cause of arrest and age. Ambulance personnel in Stockholm and Göteborg have used identical guidelines for exclusion, i.e. when not to start resuscitation. Patients with cardiac arrest prior to the arrival of the ambulance as well as during ambulance transport were included in the survey. Furthermore, the criteria for terminating CPR are the same in both cities and the decisions to do so could only be taken by the mobile care unit personnel. Protocols were completed on all cases of cardiac arrest, but patients in whom no resuscitation attempts at all were made have been excluded in this study as were patients who suffered from in-hospital cardiac arrest. The patients admitted alive to the hospitals were further studied with regard to medical history and risk factors. Patients admitted alive were defined as patients admitted alive from the emergency departments to the hospitals wards and who accordingly had not been declared dead in the emergency rooms.

2.4. Definitions

Acute myocardial infarction (AMI) was diagnosed if two of the three following conditions were fulfilled: (1) chest pain, (2) elevated serum enzyme activity specific to myocardial damage (various enzymes were used during the period studied), (3) development of Q-waves in at least 2 leads in a 12-lead standard electrocardiogram. In our internal nomenclature for data collection, a possible myocardial infarction in connection with an OHCA denotes cardiac arrest in combination with elevated serum cardiac enzymes or in combination with dynamic ECG changes suggestive of AMI.

Cerebral Performance Categories (CPC) were classified as follows: (1) good cerebral performance, (2) moderate cerebral disability, (3) severe cerebral disability, (4) coma and (5) brain death (verified at angiography).[10] CPC scores were determined retrospectively when reviewing notes of examination.

3. Statistical methods

The distribution of continuous variables is given as mean ± standard deviation and median. For comparisons between two groups in terms of ordered and continuous variables, Fisher's non-parametric permutation test was used. For comparisons of dichotomous variables between two groups, Fisher's exact test was used. A p-value of less than 0.05 was regarded as significant. Two-tailed tests were applied. Kaplan–Meier curves were used for assessing long-term survival.

Logistic regression was used, in a backward stepwise selection mode to identify clinical factors predictive of in-hospital mortality, and for calculation of adjusted odds ratio for the relation between the two regions.

The following variables were entered: (1) age; (2) sex; (3) ischaemic heart disease (IHD); (4) diabetes mellitus; (5) congestive heart failure (CHF); (6) previous stroke; (7) chronic obstructive pulmonary disease (COPD); (8) hypertension; (9) confirmed AMI as final diagnosis; (10) unconsciousness on arrival at the ER; (11) assisted breathing on arrival at the ER; (12) ongoing CPR on arrival at the ER; (13) palpable pulse on arrival at the ER; (14) sinus rhythm on arrival at the ER; (15) treatment in the emergency room: defibrillation; (16) treatment in the emergency room: adrenaline (epinephrine); (17) treatment in the emergency room: atropine.

4. Results

In all, there were 1542 OHCA in Stockholm and 546 OHCA in Göteborg during the study period. The incidence was 34 per 100,000 inhabitants per year in Stockholm and 47 per 100,000 inhabitants per year in Göteborg.

A total number of 153 (28%) patients were admitted alive in Göteborg whereas 253 (16%) patients were admitted alive in Stockholm ($p < 0.0001$).

4.1. Patient demography and medical history

The patients admitted alive were studied further with regard to medical history and risk factors. The two groups were similar in terms of age, sex and medical history prior to the index event. Almost identical percentages of smokers and chronic alcoholism were observed. Furthermore, the use of long-term medication at the time of cardiac arrest was similar in the two groups. Ninety-seven percent in Göteborg and 98% in Stockholm were considered to have CPC score 1 (or 2) prior to cardiac arrest (Table 1).

4.2. Pre-hospital course and location of cardiac arrests

Pre-hospital data are displayed in Tables 2 and 3. Almost all intervals measured were significantly longer in Stockholm, both when comparing all patients or admitted patients only.

Sixty-two percent of all victims in Göteborg were reached by an ambulance within 5 min after call versus 29% in Stockholm ($p < 0.0001$).

Ventricular fibrillation (VF) as the initial rhythm registered, was more common in Göteborg (29% versus 19%, $p = 0.00002$). In Göteborg, 36% of the patients found with VF were defibrillated ≤ 5 min after call versus only 9% in Stockholm ($p < 0.0001$).

The majority of cardiac arrests in both cities occurred at home and during day-time. Furthermore, the two groups were similar in terms of the proportion of victims with witnessed arrests.

When studying patients admitted alive, the two groups were similar in terms of proportion of victims with CPR started prior to arrival of the ambulance. However, when comparing all OHCA, there was a significantly higher proportion of patients in Stockholm receiving CPR prior to arrival of the ambulance (36% versus 30%, $p = 0.029$).

4.3. Status on admission at the emergency room

The clinical findings at the time of admission to the emergency room for patients admitted alive are described in Table 4. On admission, a significantly higher proportion of patients admitted alive in Stockholm were unconscious ($p = 0.0056$), receiving assisted ventilation ($p = 0.0084$) and ongoing CPR ($p = 0.0002$).

The initial ECG-patterns with signs of acute ischaemia did not differ between the two groups. ST elevation was present in 33% of the patients in Göteborg and 27% of the patients in Stockholm (non-significant).

4.4. In-hospital treatment, investigations and neurological status

No significant differences were found between the two groups regarding patients subjected to acute investigations such as coronary angiography and echocardiography or acute interventions such as thrombolysis, percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) (Table 5). When comparing patients with CPC scores 1 and 2 only, the proportion of patients undergoing acute interventions was evidently higher, however, the absence of differences between the groups remained. Furthermore, subacute investigations and interventions such as exercise testing, electrophysiological testing, CABG operations and implantable cardioverter-defibrillator (ICD) were performed in a similar proportion of cases.

4.5. Survival, diagnosis and cause of death

Information on survival was available for 100% of patients in Stockholm and Göteborg. Total survival

Table 1 Patient demography and medical history (admitted patients only)

	Stockholm (n=253)	Göteborg (n=153)	p
Age (years)			
Mean (S.D.)	66.9 (16.3)	66.9 (16.3)	
Sex (%)			
Men (n)	62 (155)	65 (99)	
History of (%)			
IHD	33[a]	36	
Hypertension	25	23	
Diabetes mellitus	17	16	
Congestive heart failure	21	20	
Stroke	17	11	
COPD	20	15	
Smoking	29[b]	29[a]	
Chronic medication at time of cardiac arrest (%)			
Beta-blockers	28[a]	31	
Calcium antagonists	12[a]	10	
Diuretics	36[a]	32	
Digitalis	11[a]	13	
Other anti-arrhythmic drugs	5[a]	1	
ACE inhibitors/ARB	19[a]	19	
Salicylates	25[a]	30	
Anticoagulants	11[a]	12	
Lipid-lowering drugs	12[a]	8	
Psychopharmaceutical agents	6[b]	12	
Beta-stimulants	16[a]	10	
CPC score before cardiac arrest (%)			
1	91	90[a]	
2	7	7[a]	

p-Values denoted only if <0.05. IHD, ischeamic heart disease; COPD, chronic obstructive pulmonary disease; ACE, angiotensin converting enzyme; ARB, angiotensinreceptor-blockers; CPC, cerebral performance category.
[a] Proportion of patients with missing information between 10 and 25%.
[b] Proportion of patients with missing information >25%.

to discharge after OHCA during the study period was 6.1% in Göteborg and 3.3% in Stockholm (p=0.01). The significant difference in survival remained at a 3-year follow up: 5.5% versus 2.3% (p=0.0007).

Of the patients admitted alive to hospital, 20% (51 patients) survived to discharge in Stockholm, versus 22% (33 patients) in Göteborg (non-significant). One and three year survival data are displayed in Tables 2 and 3.

For patients admitted alive, acute myocardial infarction (AMI) was determined as the final diagnosis and cause of cardiac arrest in 60% in Stockholm compared with 50% in Göteborg. Conversely, in Göteborg 13% of the patients were judged to have probable myocardial ischaemia (but no AMI) compared to 3% in Stockholm (Table 5). Thus, the fraction that was judged to have an acute coronary syndrome as the underlying aetiology was identical in both cities. Of the patients admitted alive, 25% of the patients in Stockholm versus 24% of the patients in Göteborg underwent an autopsy (NS).

In the multivariate analysis described above clinical factors identified as independent predictors of in-hospital mortality were age, previous diabetes mellitus, unconsciousness, assisted breathing, and ongoing CPR on admission to hospital (Table 6). When adjusting for these factors there was a significantly higher rate of survival at discharge in the Stockholm region (OR 2.75; 95% CI: 1.29, 5.85, p=0.009) compared to Göteborg. The model included 68% of all patients.

5. Discussion

We have confirmed a substantial difference in survival after OHCA between the two largest cities in Sweden. This difference appears to be associated with pre-hospital factors rather than with in-hospital care or patient demography and medical history. Few studies have focused on in-hospital mortality after OHCA and only a handful have

Table 2 Pre-hospital course and survival for all patients

	Stockholm (n=1542)	Göteborg (n=546)	p
Initial arrhythmia (%)			
Ventricular fibrillation	19[a]	29[a]	<0.0001
Asystole	66[a]	53[a]	<0.0001
PEA	9[a]	15[a]	0.0001
Time intervals (min, median) (mean)			
Witnessed patients			
Cardiac arrest to call	5[a] (6)	3[a] (5)	0.004
All patients			
Call for to arrival of ambulance	7[a] (9)	5[a] (6)	<0.0001
Ventricular fibrillation			
Call for ambulance to first defibrillation	10[a] (11)	6[a] (8)	<0.0001
Bystander initiated CPR (%)	36[a]	30[a]	0.029
Witnessed cardiac arrest (%)	65[a]	70[a]	
Cardiac arrest at home (%)	61	63	
Percent probable cardiac etiology (%)	59	68[a]	0.0002
Percent of patients admitted to hospital (%)	16	28	<0.0001
Patients discharged alive (%)	3.3	6.1	0.01
One-year survival (%)	2.5	6.1	0.0002
Three-year survival (%)	2.3	5.5	0.0007

p-Values denoted only if <0.05. Information on survival was available for 100% of patients in Stockholm and Göteborg. PEA, pulseless electrical activity; CPR, cardiopulmonary resuscitation.

[a] Proportion of patients with missing information between 10 and 25%.

managed to demonstrate in-hospital factors as having a direct effect on survival. To our knowledge, this is the first study that has attempted to analyse such factors and mechanisms in depth behind a difference in survival between the two largest cities in the same country.

5.1. Patient demography and medical history

The two groups of patients admitted alive were very similar in terms of age, sex, previous medical history and chronic medication prior to the index event. Patient characteristics were also similar to cardiac arrest groups studied previously in Sweden.[8,11] Age[12,13] and medical history in form of cardiac disease[14–19] have been shown to be direct risk factors for sudden cardiac death. Moreover, no significant differences were found between the two groups regarding patients subjected to acute or subacute investigations and interventions such as coronary angiography (including PCI), thrombolysis, echocardiography, exercise testing, electrophysiological testing, CABG or ICD-implantation following the index event. In one of the very few studies that have demonstrated in-hospital factors to be associated with in-hospital survival after OHCA, Engdahl et al.[11] considered some of these investigations and interventions as one of three possible groups of variables affecting the difference in hospital survival. Smoking as an independent risk factor for sudden cardiac death has been confirmed elsewhere in community based studies.[11,20–21] In our investigation the two groups had no differences in smoking incidence or chronic alcoholism.

5.2. Pre-hospital course and status on admission at the emergency room

All pre-hospital time intervals analysed were longer in Stockholm than in Göteborg, both when comparing all patients or patients admitted alive only. It is well established that early CPR can double or triple survival after OHCA.[3,5,22–24] The proportion of patients in this study receiving CPR prior to arrival of the ambulance are in accordance with those found in previous cardiac arrest studies in Sweden.[8,24] Early defibrillation has been shown to improve survival after OHCA[4,25–27] with survival numbers as high as to 74% for witnessed patients defibrillated within 3 min after arrest.[4] For every minute without CPR or defibrillation in witnessed VF, the probability of survival to discharge decreases by around 10%.[23,28] The longer time intervals in this study, especially those in

Table 3 Pre-hospital course, survival and CPC-scores for patients admitted alive to hospital

	Stockholm (n=253)	Göteborg (n=153)	p
Initial arrhythmia (%)			
Ventricular fibrillation	36[a]	41[b]	
Asystole	50[a]	46[b]	
PEA	5[a]	11[b]	
Time intervals (min, median) (mean)			
Witnessed patients			
Cardiac arrest to call	3[b] (4)	2[b] (2)	0.002
All patients			
Call for to arrival of ambulance	7[a] (8)	4[a] (5)	
Ventricular fibrillation			
Call for ambulance to first defibrillation	8.5 (9)	6[a] (7)	0.029
Bystander initiated CPR (%)	40[a]	32[b]	
Witnessed cardiac arrest (%)	83[b]	80[b]	
Cardiac arrest at home (%)	57	56[b]	
Patients discharged alive (%)			
All patients	20	22	
VF/VT	29	35	
No VF/VT	5	5	
Bystander witnessed	15	22	
Bystander witnessed with VF/VT	32	36	
CPC score at discharge (%)			
1	64	63	
2	26	22	
One-year survival for patients discharged alive (%)	74	100	0.0014
Three-year survival for patients discharged alive (%)	70	88	

p-Values denoted only if <0.05. Information on survival was available for 100% of patients in Stockholm and Göteborg. PEA, pulseless electrical activity; CPR, cardiopulmonary resuscitation; VF, ventricular fibrillation; VT, ventricular tachycardia; CPC, cerebral performance category

[a] Proportion of patients with missing information > 25%.

[b] Proportion of patients with missing information between 10 and 25%.

Stockholm, doubtlessly explain the low number of patients found in VF. Most certainly, the significant difference in survival between Stockholm and Göteborg derives from a significant difference in VF incidence on ambulance arrival. The possible explanations for the lengthy time intervals occurring in Stockholm compared with Göteborg have been discussed elsewhere.[8]

A significantly higher proportion of patients admitted alive in Stockholm were unconscious and were receiving assisted breathing and CPR on arrival to the emergency room.

5.3. Survival, diagnosis and cause of death

Total survival to discharge from hospital was almost twice as high in Göteborg than in Stockholm: 6.1% versus 3.3%. The most likely explanation for this difference is the delay in pre-hospital care as there was no difference in patient demography, medical history or in-hospital mortality (80% in Stockholm and 78% in Göteborg). A study from Norway[12] that found remarkable discrepancies in survival between four hospital regions is one of the few studies which has identified in-hospital variables related to survival. The four different predictors of a worsened outcome were high body temperature, elevation of blood glucose, acidosis and seizures. A Finnish retrospective study from 2003[29] of 98 patients admitted alive after VF OHCA demonstrated age, delay before sustained return of spontaneous circulation, mean blood glucose and potassium concentrations, and the use of beta-blocking agents as independent variables associated with survival for 6 months. In our study, an analysis of these variables presented in the Norwegian and Finnish studies was not made as these results were not available in the database. This, certainly, is a limitation. In Stavanger, i.e. one of the four regions included in the Norwegian study,

Table 4 Patient characteristics on admission to hospital at the emergency room (admitted patients only)

	Stockholm (n=253)	Göteborg (n=153)	p
Unconscious patients (%)	96	91	0.006
Spontaneous breathing (%)	27	40	0.008
Ongoing CPR (%)	22[a]	7	0.0002
Palpable pulse (%)	90	93	
Initial ECG pattern (%)			
Signs of acute ischemia	53[a]	58	
ST-elevation	27[b]	33	
Initial rhythm (%)			
Supraventricular rhythm	85[a]	84	
Ventricular tachycardia	5[a]	4	
Ventricular fibrillation	3[a]	2	
Asystole	1[a]	0	
PEA	0[a]	1	
Other	6[a]	8	
Treatment in the emergency room (%)			
Defibrillation	11	8	
Adrenaline	16	9	
Atropine	10	6	

p-Values denoted only if <0.05. CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity.
[a] Proportion of patients with missing information between 10 and 25%.
[b] Proportion of patients with missing information >25%.

Table 5 In-hospital treatment and diagnosis

	Stockholm (n=253)	Göteborg (n=153)	p
Intervention/investigation, all patients (%)			
Thrombolysis	7	5	
Coronary angiography	12	16	
PCI	7	10	
CABG	2	3	
Echocardiography	33	38	
Exercise stress test	5	3	
Electrophysiological testing	2	3	
ICD	3	4	
Intervention/investigation among patients with CPC score 1 or 2 (%)			
Thrombolysis	22[a]	16	
Coronary angiography	55	63	
PCI	28	37	
CABG	10	11	
Echocardiography	72	74	
Exercise stress test	24	15	
Electrophysiological testing	10	15	
ICD	14[a]	22	
Final diagnosis, cause of cardiac arrest (%)			
Confirmed AMI	60	50	
No AMI but probably myocardial ischemia	3	13	0.0002
Other genesis	37	37	

p-Values denoted only if <0.05. PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; AMI, acute myocardial infarction; ICD, implantable cardioverter-defibrillator.
[a] Proportion of patients with missing information between 10 and 25%.

Table 6 Results of the logistic regression analysis (identification of predictors of in-hospital mortality)

	OR (95% CI)	p
Age ≥ 70 years	2.79 (1.44, 5.43)	0.002
Diabetes mellitus	3.03 (1.08, 8.49)	0.03
Unconsciousness (on admission to the ER)	14.96 (3.89, 57.56)	<0.0001
Assisted breathing (on admission to the ER)	3.85 (1.88, 7.87)	0.0002
Ongoing CPR (on admission to the ER)	8.20 (1.62, 41.59)	0.01

OR, odds ratio, CI, confidence interval. The model included 68% of all patients.

20% of the patients were discharged alive in contrast to the 3.3% in Stockholm. This large difference in survival can only in part be explained by the shorter time intervals occurring in Stavanger and other contributing reasons for these large differences remain unidentified.

Compared to our previous study (JIM 05),[8] 12 additional months of OHCA were analysed in order to achieve greater power and statistical legitimacy. A corresponding analysis using only the first 18 months in the present study was performed (non-published data) with similar results and conclusions to those presented in this 30-month analysis. During the last year of analysis total survival after OHCA in Stockholm improved slightly, whilst total survival in Göteborg slightly decreased. This is the most probable reason for the reduction from an almost 3-fold difference in survival (observed in the previous study) to the 2-fold difference described in this study. Inclusion criteria were identical in both studies.

Results from the logistic regression indicate a lower rate of in-hospital mortality in the Stockholm region after adjustment of independent predictors of survival. Despite this, the total mortality was significantly higher in Stockholm indicating that pre-hospital factors played the major role in predicting mortality. Due to the amount and unbalance between regions regarding missing data all results from the multivariate analysis should be interpreted with great caution. The multivariate analysis, nevertheless, strengthens our concluding interpretation that a significant higher survival after OHCA in Göteborg compared to that in Stockholm is primarily associated with pre-hospital factors.

In-hospitals interventions (such as coronary angiography, PCI, thrombolysis, CABG) were not included in the multivariate analysis due to the fact that these interventions were not performed in the very acute phase of the hospital stay in a large number of cases. For instance, a majority of all coronary angiographies were performed more than 24 h after admission to hospital (non-published data). Consequently, selection bias towards survivors is apparent and a multivariate analysis including also in-hospital interventions was judged to be inadequate.

The 1-year survival of patients discharged alive from hospital in Göteborg was 100% compared to 74% in Stockholm. The reasons for this difference are unknown. However, in a 3-year follow-up, we found no remaining significant difference in survival among patients discharged alive. The difference in total survival between Göteborg and Stockholm found in this study thus remained significant after 3 years. Other studies have shown that long-term survival among patients who have undergone rapid defibrillation after OHCA is similar to that among age-, sex- and disease-matched patients without previous OHCA.[30] Data from our study are consistent with these findings.

It is well established that the risk of sudden death from cardiac causes is increased among patients with previous myocardial infarction and reduced left ventricular systolic function.[18] In our study, 63% of patients in both groups were judged to have either acute myocardial infarction (AMI) or myocardial ischaemia without AMI as final diagnosis and cause of cardiac arrest. Approximately 33% of the patients in both groups presented with ST-elevation in addition to approximately 25% of the patients presenting with other electrocardiographic signs of acute ischaemia. However, only 19% of the patients in Stockholm and 21% in Göteborg underwent revascularisation procedures (thrombolysis or coronary angiography) during their hospital stay. Impaired consciousness is the most probable explanation for these low figures as revascularisation efforts were performed in almost 80% of patients with CPC scores 1 and 2 during hospital stay. Acute coronary artery occlusions are common in survivors of OHCA and furthermore poorly recognised by clinical and electrocardiographic findings. It seems that immediate coronary angiography followed by coronary angioplasty in suitable candidates improves survival.[31] There is, however, no randomised study as of today with survival data supporting this hypothesis. A number of studies are

presently evaluating the effect of thrombolysis during CPR in patients with OHCA.

The rapid developments of pre-hospital strategies such as public-access defibrillation,[32] defibrillation initiated by policemen[33,34] and other first responders, an increased use of CPR guidance by telephone from dispatchers to bystanders[35] and recently released updated guidelines for resuscitation[36] will probably have the beneficial consequence of a larger proportion of patients being admitted alive after OHCA. Accordingly, the in-hospital phase after OHCA will most likely become increasingly important. As a result, new guidelines for post-resuscitation care with specific protocols for in-hospital care were published in September 2005.[37] More studies are, however, needed for the establishment of new in-hospital factors associated with survival.

6. Limitations

(1) In this study, we did not use a recognised coma/neurological rating scale and used a broad categorisation scale instead. This is probably an insensitive predictor of outcome and one cannot exclude that a more sensitive scoring system would have revealed more differences between the two groups.
(2) Socioeconomic differences have not been accounted for.
(3) Information on some variables was lacking in a proportion of patients, particularly in regard to time intervals for bystander witnessed cardiac arrests. Therefore, these data should be interpreted with caution.
(4) A substantial number of in-hospital variables that could influence survival, such as body temperature, s-glucose levels, base excess levels and other laboratory tests were not available in the database.

7. Conclusion

Total survival to discharge after OHCA in Göteborg (6.1%) is almost twice as high as in Stockholm (3.3%), whereas in-hospital survival is almost identical in these cities (22% versus 20%). We have found no in-hospital factors or patient characteristics (including medical history and chronic medication) associated with increased survival. Thus, the difference in survival between the two largest cities in Sweden appears to be related to pre-hospital factors (predominately prolonged time intervals in Stockholm) only.

Conflict of interest statement

None.

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ORIGINAL ARTICLE

Validation of a Rule for Termination of Resuscitation in Out-of-Hospital Cardiac Arrest

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ABSTRACT

BACKGROUND

We prospectively evaluated a clinical prediction rule to be used by emergency medical technicians (EMTs) trained in the use of an automated external defibrillator for the termination of basic life support resuscitative efforts during out-of-hospital cardiac arrest. The rule recommends termination when there is no return of spontaneous circulation, no shocks are administered, and the arrest is not witnessed by emergency medical-services personnel. Otherwise, the rule recommends transportation to the hospital, in accordance with routine practice.

METHODS

The study included 24 emergency medical systems in Ontario, Canada. All patients 18 years of age or older who had an arrest of presumed cardiac cause and who were treated by EMTs trained in the use of an automated external defibrillator were included. The patients were treated according to standard guidelines. Characteristics of diagnostic tests for the prediction rule were calculated. These characteristics include sensitivity, specificity, and positive and negative predictive values.

RESULTS

Follow-up data were obtained for all 1240 patients. Of 776 patients with cardiac arrest for whom the rule recommended termination, 4 survived (0.5 percent). The rule had a specificity of 90.2 percent for recommending transport of survivors to the emergency department and had a positive predictive value for death of 99.5 percent when termination was recommended. Implementation of this rule would result in a decrease in the rate of transportation from 100 percent of patients to 37.4 percent. The addition of other criteria (a response interval greater than eight minutes or a cardiac arrest not witnessed by a bystander) would further improve both the specificity and positive predictive value of the rule but would result in the transportation of a larger proportion of patients.

CONCLUSIONS

The use of a clinical prediction rule for the termination of resuscitation may help clinicians decide whether to terminate basic life support resuscitative efforts in patients having an out-of-hospital cardiac arrest.

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THE SURVIVAL RATE AFTER OUT-OF-HOSPITAL cardiac arrest is low, especially among patients who have no response to advanced cardiac life support provided by paramedical personnel.[1] Several retrospective studies have identified patients for whom termination of resuscitative efforts outside the hospital can be considered after resuscitative efforts by paramedics trained and equipped to provide advanced cardiac life support have failed.[2-13] As a result, guidelines exist for the termination of resuscitation in this setting, and most emergency medical services (EMS) systems have protocols to permit the practice.[14]

However, because of a lack of data, similar guidelines have not been developed for use when basic life support is provided by emergency medical technicians (EMTs) trained in the use of an automated external cardiac defibrillator. As a result, substantial numbers of patients with little or no potential for survival are regularly transported to emergency departments. Guidelines for EMTs trained in the use of an automated external defibrillator would be extremely useful, since a survey indicated that several cities in the United States have EMS systems that consist in whole or in part of EMTs thus trained.[15]

We recently derived a clinical prediction rule for the termination of basic life support resuscitative efforts by EMTs trained in the use of an external cardiac defibrillator on the basis of a retrospective review of case records from a large, urban EMS system.[16] The presence of three clinical variables identified patients who did not survive out-of-hospital cardiac arrest. The prediction rule proposed that in the absence of available equipment and personnel to provide advanced cardiac life support, termination of resuscitative efforts could be considered in the out-of-hospital setting if there was no return of spontaneous circulation before transportation was initiated, no shock was given before transportation was initiated, and the arrest was not witnessed by EMS personnel (e.g., a firefighter or an EMT). When applied retrospectively to the study population from which it was derived, the prediction rule had a sensitivity of 100 percent for identifying patients who survived to hospital discharge.[16]

Any prediction rule that is derived in a retrospective fashion requires prospective validation before it is implemented clinically.[17,18] Accordingly, we used methods of prospective validation to test the predictive value of this rule. The secondary objective was to evaluate whether a response interval of more than eight minutes (a criterion proposed on the basis of a retrospective study by Petrie et al.[19]) would increase the predictive power of the rule.

METHODS

STUDY DESIGN

The study was conducted to validate a clinical prediction rule according to the method described by Wasson et al.[17] and Laupacis et al.[18] A total of 12 urban and rural regions in Ontario, Canada, served by 24 EMS systems participated in the study. The regions included areas ranging in population from 40,000 to 2.5 million persons, with population densities ranging from 8 to 3939 persons per square kilometer. All participating EMS systems received approval from the regional institutional ethics board. Because of the clinical setting, the standard requirement of written informed consent was waived.

STUDY POPULATION

The study population was made up of consecutively enrolled adult patients (persons 18 years of age or older) who were treated for an out-of-hospital arrest of presumed cardiac cause[20] between January 1, 2002, and January 30, 2004. Patients who had a cardiac arrest were evaluated and given basic life support exclusively by an EMT trained in the use of an automated external defibrillator. We excluded patients who received advanced cardiac life support (e.g., intubation and administration of intravenous fluids and medication), those who had a written or oral do-not-resuscitate order, and those who had an arrest attributable to an obvious cause (e.g., trauma or asphyxia).[20] Prehospital care was documented with the use of a standard call-report form used by ambulance personnel throughout the province of Ontario.

RESUSCITATION ALGORITHM

The protocol for basic life support included the use of an automated external defibrillator and conformed with the recommendations of the American Heart Association and the International Liaison Committee on Resuscitation.[21] In accordance with these recommendations, all patients received cardiopulmonary resuscitation, with paus-

es every one or two minutes to assess rhythm with an automated external defibrillator and to deliver a shock as dictated by the automated analysis of the defibrillator. The rhythm was analyzed no more than three times, with the delivery of no more than three shocks at each analysis, as indicated. On either successful defibrillation or the completion of this algorithm, the patient was rapidly transported to the hospital and cardiopulmonary resuscitation was continued, if necessary.

STUDY PROTOCOL

Before the start of the study, all EMTs trained in the use of an automated external defibrillator received instruction in the prediction rule. After a patient was transferred to the receiving hospital, the EMTs completed a data-collection form that included all relevant clinical characteristics of the cardiac arrest as well as the elements of the prediction rule. Patients were categorized according to the recommendations of the prediction rule. For patients treated with the complete resuscitation algorithm who had no return of spontaneous circulation before the initiation of transport to the hospital, those who had not received any shocks before transport was initiated, and those whose cardiac arrest was not witnessed by EMS personnel (a firefighter or an EMT), the rule recommended the termination of resuscitation. On the data-collection form, this recommendation was designated by the term "terminate." Otherwise, the prediction rule recommended continued basic life support resuscitation efforts and transportation to the hospital, as designated by the term "transport."

Study coordinators at each study site reviewed the data-collection forms for accuracy before they were sent to a central coordinating office. The data were abstracted by four trained abstractors using a standardized form. Problems related to missing, unclear, or ambiguous data were resolved by querying the site for additional information. Definitions used in the data-collection form conformed to the Utstein style of reporting a cardiac arrest, when possible.[20]

OUTCOME MEASURES

Study coordinators at each site obtained information on patients' outcomes from the receiving hospitals six to eight months after the cardiac arrest. Outcomes were categorized as follows: the patient was pronounced dead in the emergency department, died after admission to the hospital, was alive in the hospital at six months, or had been discharged from the hospital. The outcomes were analyzed as a binary measure of "died" (the first two outcomes) or "survived" (the last two outcomes). Cerebral performance (Table 1)[22,23] was also assessed, either at discharge from the hospital or at six months for those in the hospital at that point.

Table 1. Categories of Cerebral Performance.*

Category	Classification	Description
1	Good cerebral performance	Patient is conscious, alert, and able to work and lead a normal life. Patient may have minor psychological or neurologic deficits (e.g., mild dysphasia, hemiparesis that is not incapacitating, or minor cranial-nerve abnormalities).
2	Moderate cerebral disability	Patient is conscious and has sufficient cerebral function to be able to work part time in a sheltered environment or perform activities of daily living (e.g., dress, travel by public transportation, or prepare meals) independently. Patient may have hemiplegia, seizures, ataxia, dysarthria, dysphasia, or permanent changes in memory or mental status.
3	Severe cerebral disability	Patient is conscious, dependent on others for daily support (in an institution or at home with an exceptional effort made by the family), and has at least limited cognitive ability. A wide range of cerebral abnormalities may be present, ranging from the ability to walk but with severe memory disturbance or dementia precluding independent living to paralysis and the ability to communicate only with the eyes (as in the locked-in syndrome).
4	Coma or vegetative state	Patient is unconscious, unaware of surroundings, and without cognitive ability; no verbal or psychological interaction with the environment.
5	Death	Patient is certified as brain dead or dead.

* Data are adapted from Safar and Bircher[22] and the Brain Resuscitation Clinical Trial II.[23]

STATISTICAL ANALYSIS

The statistical analysis was performed with SAS software (version 8.0). The prediction rule was evaluated as a diagnostic test, and test characteristics were calculated. These test characteristics include sensitivity, specificity, and positive and negative predictive values. It was assumed that an ideal test would not recommend the termination of resuscitation efforts if the patient could potentially survive cardiac arrest. Thus, the specificity of the rule (the probability that the rule suggests transport when the patient survives) and its positive predictive value (the probability of death when the rule proposes the termination of resuscitative efforts) were identified as the important test characteristics. The survival rate among patients for whom the prediction rule recommended the termination of resuscitation was also determined. Similar analyses were performed with the addition to the prediction rule of the prespecified variable of an EMS response interval of more than eight minutes, as well as the addition of the post hoc variable of a cardiac arrest that was not witnessed by a bystander.

The estimated sample size was calculated on the basis of a survival rate of 1 percent or less when the prediction rule recommended the termination of resuscitation. This survival rate of 1 percent or less has been suggested as reflective of medical futility.[24] The rate of survival to discharge from the hospital was estimated to be 0.3 percent when the prediction rule suggested termination of resuscitation. This estimate of 0.3 percent was derived from our previous study involving a single EMS system.[16] For a one-tailed test of significance at the 0.05 level, 773 subjects were required to provide a one-sample test of proportions with a statistical power of at least 80 percent to detect a survival rate significantly lower than 1.0 percent (PASS 2000 Power Analysis and Sample Size software).

RESULTS

During the survey period, 1620 eligible out-of-hospital cardiac arrests were recorded; EMTs did not complete a data-collection form in 379 cases, and in 1 case, the elements of the prediction rule could not be assessed on the basis of the information provided. A total of 1240 patients with cardiac arrest were therefore enrolled. The 12 participating sites had an overall enrollment rate of 76.5 percent, ranging from 21.1 to 100 percent at each site.

Table 2 shows the demographic characteristics of 1240 patients and selected features of each cardiac arrest. The mean age of the patients was 69.2 years, and 855 were men (69.0 percent). The cardiac arrest was witnessed in 712 cases (57.4 percent), and the median time to a response by the EMS team was 8.0 minutes. With respect to the variables included in the clinical prediction rule, of 1240 cardiac arrests reported, there was no return of spontaneous circulation in 1172 cases (94.5 percent), no shocks were delivered in 868 cases (70.0 percent), and the cardiac arrest was not witnessed by EMS personnel in 1120 cases (90.3 percent).

Follow-up data were obtained on all the patients enrolled in the study (Table 3). A total of 1140 patients with a cardiac arrest (91.9 percent) were pronounced dead in the emergency department, 59 (4.8 percent) died after admission to the hospital, 2 (0.2 percent) were still in the hospital at the six-month follow-up, and 39 (3.1 percent) survived to discharge.

The characteristics of diagnostic tests for the prediction rule are shown in Table 4. For 37 of the 41 patients who survived, the prediction rule recommended transportation to the hospital and continuing basic life support resuscitative efforts, resulting in a specificity of 90.2 percent (95 percent confidence interval, 88.4 to 91.8 percent). For 772 of 1199 patients who died, the prediction rule recommended the termination of resuscitation, resulting in a sensitivity of 64.4 percent (95 percent confidence interval, 61.6 to 67.0 percent). Of 776 patients for whom the prediction rule recommended the termination of resuscitation, 772 died, resulting in a positive predictive value of 99.5 percent (95 percent confidence interval, 98.9 to 99.8 percent). The prediction rule recommended transportation to the emergency department for 464 patients, of whom 37 survived, resulting in a negative predictive value of 8.0 percent (95 percent confidence interval, 6.6 to 9.7 percent).

Of the 776 patients for whom the prediction rule recommended the termination of basic life support resuscitation efforts, 4 survived (0.5 percent; 95 percent confidence interval, 0.1 to 0.9 percent). This survival rate was significantly lower ($P=0.04$) than the threshold of 1 percent that has been suggested as reflective of medical futil-

Table 2. Characteristics of Patients and Selected Features of Cardiac Arrests Included in the Study.*

Characteristic	No. of Responses	Value
Patients	1175	
Age — yr		
Mean		69.2±14.1
Range		18–100
Male sex — no. (%)	1240	855 (69.0)
Cardiac arrest witnessed — no. (%)	1240	
By bystander		571 (46.0)
By firefighter		42 (3.4)
By EMT		99 (8.0)
Cardiopulmonary resuscitation performed by bystander — no. (%)		331 (26.7)
EMS intervals — min†		
EMS response	1230	
Median		8.0
Interquartile range		5.0–12.0
Patient response	1226	
Median		9.0
Interquartile range		6.0–13.0
Transportation to emergency department	1235	
Median		6.0
Interquartile range		3.0–11.0
EMS response of ≤8 min — no. (%)		654 (53.2)
Prediction-rule variables — no. (%)		
No return of spontaneous circulation		1172 (94.5)
No shock advised		868 (70.0)
Not witnessed by EMS personnel		1120 (90.3)

* Plus–minus values are means ±SD.

† The interval between the time the call is received by the responding paramedics and the arrival of the EMS vehicle at the scene of the cardiac arrest is the EMS response interval. The interval between the time the call is received by the responding paramedics and the arrival of the EMS vehicle at the scene of the patient with cardiac arrest is the patient-response interval. The interval between the time the EMS vehicle leaves the scene of the cardiac arrest and arrives at the emergency department is the transportation to the emergency department interval.

ity.[24] Of these four patients, three were discharged home or to a long-term care facility and were considered to have good cerebral performance (category 1) and one patient had severe cerebral disability (category 3).

Additional variables were added to the original prediction rule to see if the rate of survival could be further refined. The inclusion of the prespecified variable of a response by EMS personnel in more than eight minutes was associated with a survival rate of 0.3 percent among patients for whom the rule recommended the termination of resuscitation (Table 5). The addition of this variable to the original prediction rule increased the positive predictive value to 99.7 percent and increased the specificity to 97.6 percent.

The inclusion of the post hoc variable of a cardiac arrest that was not witnessed by a bystander was associated with a survival rate of 0 percent among patients for whom the rule recommended the termination of basic life support resuscitative efforts. It increased both the positive predictive value of the rule and the specificity to 100 percent.

The addition of the prespecified variable or the post hoc variable to the original prediction rule would have increased the number of patients recommended for transportation to the emergency department. The addition of the prespecified variable increased this number from 464 (37.4 percent) to 848 (68.4 percent). The addition of the post hoc variable increased this number to 764 (61.6 percent).

Table 3. Outcomes of 1240 Reported Cardiac Arrests.

Outcome	No. (%)
Death	1199 (97)
Deaths pronounced in the emergency department	1140 (92)
Deaths after admission	59 (5)
Survival	41 (3)
In hospital at 6 mo after cardiac arrest	2 (<1)
Discharged	39 (3)
Category of cerebral performance*	
Good performance	29 (71)
Moderate disability	5 (12)
Severe disability	6 (15)
Coma, vegetative state	1 (2)

* Values for categories of cerebral performance were calculated as percentages of the 41 survivors.

DISCUSSION

We prospectively evaluated a previously derived clinical prediction rule for the termination of basic life support resuscitative efforts in out-of-hospital cardiac arrests in the absence of advanced cardiac life support. The prediction rule indicates that EMTs may consider the termination of resuscitation if there is no return of spontaneous circulation before a patient is transported to the emergency department and if the patient received no shocks before transportation was initiated and had a cardiac arrest that was not witnessed by EMS personnel responding to the call. The prediction rule had a positive predictive value of 99.5 percent and a specificity of 90.2 percent. Among patients whose condition met these three criteria, the survival rate was 0.5 percent. The prediction rule would have resulted in the transportation of 37.4 percent of patients (464 of 1240), rather than the current rate of 100 percent.

Three aspects of the overall survival rate of 0.5 percent among these patients should be mentioned. First, current guidelines for the termination of resuscitative efforts are based on retrospective literature that reported survival rates of 0.4 to 1.9 percent when the guidelines suggested the termination of resuscitative efforts.[4,7,25] Second, the survival rate of 0.5 percent falls below a previously suggested threshold of less than 1 percent for medical futility.[24] This definition of medical futility has been questioned,[26] particularly in the field of resuscitation.[27] However, such a view simply raises the question of how many times failure must occur before an intervention is considered futile.[28] Finally, we consider that our prediction rule offers guidance for clinicians but is not obligatory. In an editorial published more than 20 years ago, Cummins and Eisenberg[29] suggested that prediction rules for the termination of resuscitation efforts should remain advisory and that they should be tempered by the full clinical picture, taking into account the very small possibility of successful resuscitation when the prediction rules suggest termination.

When the prediction rule was modified to include either the prespecified variable (a response by EMS personnel in more than eight minutes) or post hoc variable (a cardiac arrest that is not witnessed by a bystander), the positive predictive value and the specificity were increased. Addition of either of the two variables would have identified most or all four of the survivors for whom the termination of basic life support resuscitative efforts was recommended. The addition of these variables also increased the proportion of patients for whom the rule would suggest transportation to the emergency department. The number of patients needed to be transported for one patient to survive was also increased. In the derivation study, neither of these additional variables added a predictive value that was not provided by other variables.[16] Measurement of the response interval was also considered too unreliable to justify inclusion in the rule,[30] and response intervals are not routinely available to EMTs before the patient is treated.

Clinical prediction rules for the termination of basic life support resuscitative efforts in out-of-hospital cardiac arrest are desirable for many reasons. The transportation of a patient with a refractory cardiac arrest limits the availability of EMS personnel to care for other patients, increases patients' waiting times in emergency depart-

Table 4. Test Characteristics of the Clinical Prediction Rule for the Termination of Resuscitation (TOR) in 1240 Reported Cardiac Arrests.*

Action According to Prediction Rule	Outcome		
	Death	Survival	Total No. of Cardiac Arrests
Terminate basic life support (test positive)	772	4	776
Transportation to emergency department (test negative)	427	37	464
Total	1199	41	1240
Survival rate when termination recommended by TOR — % (95% CI)	0.5 (0.1–0.9)		
Sensitivity — % (95% CI)†	64.4 (61.6–67.0)		
Specificity — % (95% CI)‡	90.2 (88.4–91.8)		
Positive predictive value — % (95% CI)§	99.5 (98.9–99.8)		
Negative predictive value — % (95% CI)¶	8.0 (6.6–9.7)		

* CI denotes confidence interval.
† Value is the number of cases in which the patient died when the rule recommended the termination of basic life support resuscitative efforts divided by the total number of cases in which the patient died.
‡ Value is the number of cases in which the patient survived when the rule recommended transportation to an emergency department and continuation of basic life support resuscitative efforts divided by the total number of cases in which the patient survived.
§ Value is the number of cases in which the patient died when the rule recommended the termination of basic life support resuscitative efforts divided by the total number of cases in which the rule recommended termination.
¶ Value is the number of cases in which the patient survived when the rule recommended transportation to an emergency department and continuation of basic life support resuscitative efforts divided by the total of number of cases in which the rule recommended transportation.

ments, decreases the available beds and equipment in emergency departments and hospitals,[2] and diverts care from patients who are potentially more likely to survive. Emergency "lights and sirens" transportation by ambulance carries many risks to motorists, pedestrians, and the EMS personnel, including that of vehicular collisions.[31] In addition, EMS personnel performing interventions in a moving vehicle or engaged in resuscitative efforts are at increased risk for occupational biohazards.[32] For the health care system, there are fewer costs involved in the termination of resuscitation in the field than in the transferal of the patient to the emergency department.[2,4,33,34] Provision of advanced cardiac life support in the hospital is associated with a considerable expense, approaching $1 billion annually in the United States.[2] Finally, rates of termination of resuscitative efforts vary for different regions, paramedics, and physicians when the decision to cease such efforts is left to the discretion of the health care provider, rather than being in accordance with a clinical prediction rule.[35] Eckstein et al. reported significant variability in the rates of termination of resuscitation (5 to 37 percent) between cases in which as a matter of policy physicians delegate the decision to paramedics by telephone and cases in which the decision was left to the discretion of the health care provider.[35] Use of a clinical prediction rule may allow distributive justice to be applied equally among all patients having an out-of-hospital cardiac arrest — in practical terms, the decision to terminate resuscitation would be applied equitably in this population whether it was applied by a physician, a paramedic, or EMS personnel.

The EMS system of care needs to consider the effects of an out-of-hospital death on a family who receives notification and on the paramedic who notifies the family. Surveys suggest that family members are comfortable with the decision to terminate resuscitative efforts in and out of the hospital setting,[36] and several studies have shown that medical personnel who are not physicians can convey the message regarding a death effectively to family members.[37] Future research should aim to measure with a validated instrument the psychological comfort of the EMS provider who is terminating resuscitation efforts and providing notification of death to family members in the out-of-hospital setting.[38]

In our study, the site-specific rate of the enrollment ranged from 21 to 100 percent of all eligible patients who had a cardiac arrest, with

Table 5. Outcomes of the Original Termination of Resuscitation (TOR) Prediction Rule, with Additional Prespecified and Post Hoc Variables.*

Variable	Survival When Termination Was Recommended	Positive Predictive Value	Specificity	No. (%) Transported to the Emergency Department	No. Needed to Transport†	Incremental No. Needed to Transport‡
		% (95% CI)				
Original TOR prediction rule		99.5 (98.9–99.8)	90.2 (88.4–91.8)	464 (37.4)	13	NA
No./total no.	4/776					
Rate (95% CI)	0.5 (0.1–0.9)					
Addition of EMS response that takes ≥8 min		99.7 (99.2–99.9)	97.6 (96.5–98.3)	848 (68.4)	22	128
No./total no.	1/389					
Rate (95% CI)	0.3 (0.0–1.7)					
Addition of cardiac arrest not witnessed by a bystander		100 (99.6–100)	100 (99.6–100)	764 (61.6)	19	75
No./total no.	0/476					
Rate (95% CI)	0 (0.0–1.0)					

* CI denotes confidence interval.

† The number needed to transport was calculated as the number transported to the emergency department divided by the total number of survivors, as predicted by the rule.

‡ The incremental number needed to transport was calculated by obtaining the difference between number of patients transported to the emergency department according to the original TOR prediction rule and the number transported with the additional variable and then dividing this difference by the number of additional survivors predicted according to the revised rule.

an overall rate of 76.5 percent. Data were not included for patients who were not included in the overall sample. However, data on 89 to 100 percent of all eligible patients were available at the four largest sites, and the demographic characteristics of the patients and the survival rates were similar at all 12 sites. We therefore suggest that the missed cases were probably similar to those included in the study.

The study was conducted in, and is applicable to, settings in which EMS systems were staffed by EMTs trained to provide basic life support and automated external defibrillation. The prediction rule is not applicable to resuscitations involving EMTs who are trained in advanced life support or to EMTs who are not trained in the use of an automated external defibrillator. It is also not clear that the prediction rule would produce similar results if it were used in a basic life support program in which nonautomated defibrillators were used, since the administration of shocks would then depend on the provider's independent interpretation of the rhythm.

The basic life support protocols we used were consistent with the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[21] Since the completion of the study, the 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, formulated in collaboration with the International Liaison Committee on Resuscitation, have been released.[39] They differ in some respects from the basic life support protocols we used. As newer guidelines are introduced, such protocols will continue to change, in an effort to increase survival. The likely result will be an increase in the rate of the return of spontaneous circulation and the incidence of a rhythm requiring defibrillation. Thus, an increasing number of patients would receive continued resuscitative efforts and would be transported to the emergency department if the prediction rule were to be applied. Although such changes will alter the rate of transportation to the emergency department, the rule will continue to be helpful in identifying patients who are unlikely to survive despite optimized therapy.

We prospectively evaluated a clinical prediction rule for the termination of basic life support resuscitative efforts by EMTs trained in the use of an automated external defibrillator for a cohort of patients with out-of-hospital cardiac arrest and found that the rule had a positive predictive value of 99.5 percent and a specificity of 90 percent.

Among patients who fulfilled the criteria for the termination of resuscitative efforts, a total of 0.5 percent survived. The rule may assist clinicians in making decisions to terminate resuscitative efforts in out-of-hospital cardiac arrest.

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APPENDIX

The following persons and EMS systems in Ontario, Canada, participated in the study: *Steering Committee* — R. Verbeek (chair), L.J. Morrison, L.M. Visentin, D. Eby, R. Theriault; *Data Management Committee* — L.J. Morrison (chair), L.M. Visentin, M. Vermeulen, A. Kiss; *Waterloo Region–Wellington–Dufferin Base Hospital Paramedic Program* — D. Waldbillig, K. Ballah, Royal City Ambulance Service; *Associate Base Hospital Program, Eastern Counties* — L. Briere, C. Brandt, Cornwall SD&G EMS, Prescott/Russell EMS; *Base Hospital Advanced Life Support Program for Durham Region* — R. Vanderschuis, M. Epp, S. Driscoll, Durham Region EMS; *Grey–Bruce–Huron Paramedic Base Hospital Program* — D. Eby, C. Prowd, M. Mair, Grey County EMS, Bruce County EMS, Huron County EMS; *Hamilton Health Sciences Base Hospital Program* — M. Welsford, K. Stuebing, Norfolk County EMS, Haldimand County EMS, County of Brant Ambulance Service, Six Nations Ambulance Service; *Sunnybrook–Osler Centre for Prehospital Care* — P.R. Verbeek, S. Cheskes, R. Theriault, L. McCleuy, J. Summers, Toronto EMS, Peel Region Ambulance Service; *Base Hospital Program, Peterborough Regional Health Centre* — V. Arcieri, P. Mathers, City of Kawartha Lakes Ambulance Service, Haliburton EMS, Northumberland EMS; *Sault Area Hospital Base Hospital Program* — P. Hoogeveen, J. Scott, E. Mooney, Algoma EMS, Sault Ste. Marie EMS; *Royal Victoria Hospital Base Hospital for Simcoe and Muskoka* — M. Murray, T. Waite, Muskoka Ambulance Service, Health Trust Ambulance Service; *Timmins and District Base Hospital Paramedic Program* — C. Loreto, M. Pilkington, Cochrane District EMS, James Bay Ambulance Service; *York Regional Base Hospital Program* — D. Austin, W. Beckett, A. Donnelly, D. Kunihiro, York Region EMS.

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