Original Article

A Comparison of the Ability of Morbidity Scores to Predict Unsuccessful Cardiopulmonary Resuscitation in Thailand

Panita Limpawattana MD[1], Chomchanok Suraditnan MD[2], Wannaporn Aungsakul MD[2], Anupol Panitchote MD[3], Boonsong Patjanasoontorn MD[3], Anakapong Phunmanee MD[3], Nittaya Pittayawattanachai MD[4]

[1] Division of Geriatric Medicine, Department of Internal Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand
[2] Department of Internal Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand
[3] Division of Critical care, Department of Internal Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand
[4] CPR Unit, Srinagarind Hospital, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

Background: Pre-arrest morbidity [PAM] scores could be used as additional tools to help patients and healthcare providers make decisions regarding do not resuscitate [DNR] orders. There are, however, no studies that examine applicability of those scores in Thailand.

Objective: To compare the usefulness of mortality prediction scores at hospital discharge among cardiac arrest patients who received cardiopulmonary resuscitation [CPR] and to identify the optimal cutoff points of the best morbidity scores.

Materials and Methods: A retrospective chart review was conducted of all adult patients who underwent CPR from January 1, 2013 to December 31, 2014 at Srinagarind Hospital, Thailand. Demographic and clinical data to calculate the PAM score, the prognosis after resuscitation [PAR] score, and the modified PAM index [MPI] were collected.

Results: There were enough data available on one-hundred and ninety-two patients to analyze the outcomes. The overall performances of all morbidity scores according to the area under the receiver operating characteristic [ROC] curves were similar; PAM 0.65 (95% confidence interval [CI] 0.56 to 0.74), MPI 0.66 (95% CI 0.57 to 0.75), and PAR 0.6 (95% CI 0.52 to 0.70), $p = 0.5$. PAM ≥6 and MPI ≥5 were the optimal cutoff points, which provided sensitivities of 49% and 57%, respectively, and specificities of 80.5% and 73.2%, respectively.

Conclusion: PAM, MPI, and PAR scores are not sufficient tools to identify patients who would benefit from resuscitation attempts among Thai patients. Given their high specificities, a combination these tools as part of a shared-decision to identify patients in whom CPR is likely to be unsuccessful recommended.

Keywords: Cardiac arrest, CPR, PAM, PAR, Prognosis, MPI, Survival

J Med Assoc Thai 2018; 101 (9): 1231-6
Website: http://www.jmatonline.com

Cardiac arrest is a stressful event in clinical practice that can be classified as either in-hospital cardiac arrest [IHCA] or out-hospital cardiac arrest [OHCA]. Cardiopulmonary resuscitation [CPR] might be performed in patients with this condition[1,2]. CPR was originally developed to treat patients who suffered cardiac arrest as a result of potentially reversible causes such as acute myocardial infarction, drug overdose, hypothermia, and accidental drowning[3]. Nevertheless, the actual effectiveness of CPR remains poorly defined, as it is frequently attempted in patients with a low chance of survival such as those with advance cancer, end-stage renal failure, and severe dementia[4,5]. Although there are several studies that indicate improvements to cardiac arrest care, the survival outcome at hospital discharge remains small in cases of both IHCA and OHCA, even if CPR is administered in a hospital where there is adequate equipment and there are trained healthcare providers[6]. Prior studies have shown that OHCA has a much lower survival rate (5% to 10%)[6,7] at hospital discharge than IHCA (6.6% to 37%)[1-3,6,8-13]. These figures vary due to differences in inclusion criteria[12,14].

There is a chance that patients with cardiac arrest who receive CPR could be given unwarranted treatment, which could cause prolonged suffering and unnecessary healthcare costs. Identification of patients who have low chances of successful resuscitation is crucial to making a do not resuscitate [DNR] decision or terminating resuscitation in order to reduce adverse

Correspondence to:

Limpawattana P. Division of Geriatric Medicine, Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
Phone: +66-43-363664, **Fax**: 66-43-202491
Email: lpanit@kku.ac.th

How to cite this article: Limpawattana P, Suraditnan C, Aungsakul W, Panitchote A, Patjanasoontorn B, Phunmanee A, et al. A comparison of the ability of morbidity scores to predict unsuccessful cardiopulmonary resuscitation in Thailand. J Med Assoc Thai 2018;101:1231-6.

outcomes. Currently, there are numerous studies available regarding predictors of survival at hospital discharge[3,14-16], which reveal that there are multiple factors associated with outcomes including age, gender, race, ethnic, pre-existing conditions, event interval, duration of CPR, type of arrhythmia, hospital location, early defibrillation, and post-resuscitation care[3,14-16].

Morbidity scores, such as the pre-arrest morbidity [PAM] score, the prognosis after resuscitation [PAR] score, the modified PAM index [MPI], and the Good Outcome Following Attempted Resuscitation [GO-FAR] score, have been developed, mainly for IHCA[14,17-20]. The area under the receiver operating characteristic [ROC] curves of the PAM and PAR scores have been shown to be 0.67 and 0.74[20]. At PAM and PAR scores >5, specificity exceeds 90%, whereas sensitivity is only 20% to 30%[20,21]. There are no data available regarding the test characteristics of these scores similar to MPI scores[17]. The GO-FAR score was able to identify more than one-quarter of patients as having a low or very low likelihood of survival at hospital discharge following IHCA; however, no data of overall performance of the test available[19]. Thus, the use of these predictor tools as part of the decision-making process regarding DNR is recommended. However, there have been no studies that have examined the applicability of morbidity scores in Thailand. Therefore, the primary objective of the present study was to compare the performance of the PAM, PAR and MPI scores of patients with cardiac arrest who received CPR and to identify the optimal cut-off points of the best morbidity scores for predicting mortality in those patients.

Materials and Methods

Study setting and patient population

Medical records were retrospectively reviewed of patients in whom CPR was attempted at Srinagarind Hospital from January 1, 2013 to December 31, 2014 who were aged ≥18 years old. Patients with second or subsequent cardiac arrests during a single hospitalization or whose medical records had missing values were excluded. The study population was similar to that examined in the study entitled, "Long-term outcomes and predictors of survival after CPR for IHCA in a tertiary care hospital in Thailand".

Data collection

Demographic and associated clinical variables were collected from medical records, the CPR unit's cardiac arrest records, and the civil registration including age, sex, location of cardiac arrest, types of ward, length of stay, reason for admission, comorbid diseases, pre-arrest cardiac rhythm, homebound status, mechanical ventilation, whether or not someone had witnessed the arrest, initial mental status, urine output, latest blood creatinine level prior cardiac arrest, ROSC, and survival at discharge and seven days after discharge. Survival at discharge in the present study was based on survival at seven days after hospital discharge, which might not represent the actual survival status. Patients in this setting were more likely to opt to return home if their chances for survival were small.

Sample size calculation

Sample size calculation was based on the objective of the study, which was to examine the performance of the PAM, PAR, and MPI in predicting the mortality at discharge of patients with cardiac arrest who received CPR. ROC curves are used to summarize the accuracy of diagnostic tests. Therefore, calculation of the sample size was based on the area under the ROC curve [AUC] and was carried out according to the methodology espoused by Hanley and McNeil (1983)[22]. This method varies the sample size until a sufficiently small standard error of the area under the ROC curve is achieved. Because of the complexity of this formula, a web-based calculator (www.anaesthetist.com/mnm/stats/roc/#stderr) was used to determine the standard error. It was determined that a sample size of at least 190 cases, which included about 40 patients who had survived at hospital discharge and 150 who had not, was sufficient to conduct the present study at an standard error of <0.05.

Statistical analysis

Demographic data variables (which included baseline characteristics) were divided into dichotomous or polytomous variables. All variables were summarized using descriptive statistic presentation as percentage, mean, and standard deviation. However, if the distribution of this data was not normal, median, minimum, maximum, and inter-quartile ranges were used instead. The ROC curve was used to summarize the overall accuracy of the scores for predicting mortality at seven days post discharge. An optimal cut-off point was then determined. The performance of the test was summarized as sensitivity, specificity, positive predictive value [PPV], negative predictive value [NPV], and likelihood ratio. Youden's index was obtained and compared with the cut-off value for difficult intubation. All data analysis was performed

using Stata version 10.0 (Stata Corp, College Station, TX, USA).

Ethics approval

The present study was provided by the Khon Kaen University Faculty of Medicine Ethics Committee as instituted by the Helsinki Declaration.

Results

There were 278 patients enrolled in the present study. The baseline characteristics of the study population are shown in Table 1. The median age was 57.6 years, and more men were included than women. The majority of the patients had experienced IHCA, and they frequently had non-shockable cardiac rhythm. The survival rate was about 25% at hospital discharge and declined to about 20% seven days following discharge.

The performance of PAM, MPI, and PAR

Of 278 patients, sufficient data for analyzing the performance of the three morbidity scores mentioned above were available for 192 (IHCA 166 and OHCA 26 cases). The overall performance of all three morbidity scores in predicting mortality following CPR according to the area under the ROC curves was poor; AUC of PAM 0.65 (95% CI 0.56 to 0.74), MPI 0.66 (95% CI 0.57 to 0.75), and PAR 0.6 (95% CI 0.52 to 0.70) (Figure 1). In addition, there were no statistical differences among the scores' predictive abilities (p = 0.5), although PAM and MPI were better at predicting mortality in cases of out-of-hospital cardiac arrest than in cases of IHCA (Table 2).

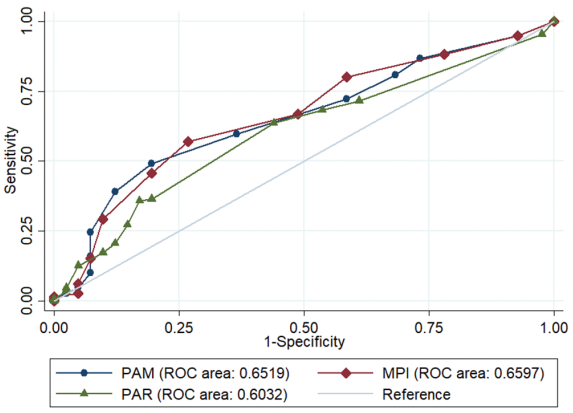

Figure 1. Receiver operating characteristic [ROC] curves of PAM, MPI, and PAR scores. PAM = pre-arrest morbidity score; MPI = modified PAM index score; PAR = prognosis after resuscitation score.

Table 1. Baseline characteristics of the patients

Variables	n = 278
Age (years), median (IQR1, IQR3)	57.6 (46, 71)
Men, n (%)	173 (62.23)
IHCA, n (%)	202 (72.66)
Ward, n (%)	
General ward	97 (34.89)
ICU	115 (41.37)
Special ward	5 (1.80)
Emergency room	61 (21.94)
LOS (days), median (IQR1, IQR3)	13.4 (3, 16)
Reasons for admission (n = 254), n (%)	
Cardiac cause	53 (20.87)
Infectious cause	61 (24.02)
Hematologic/oncologic cause	36 (14.17)
Neurological cause	8 (3.15)
Trauma	24 (9.45)
Others	72 (28.35)
Prearrest cardiac rhythm, n (%)	
Asystole	87 (31.29)
PEA	115 (41.37)
VF/VT	45 (16.19)
Others	0 (0.00)
Unknown	31 (11.15)
Underlying disease(s), n (%)	
DM	75 (26.98)
HT	97 (34.89)
MI	14 (5.04)
Solid malignancy	
• Non-metastasis	21 (7.55)
• Metastasis	16 (5.76)
Hematologic malignancy	9 (3.24)
Dementia	3 (1.08)
Cirrhosis	13 (4.68)
Homebound, n (%)	18 (6.47)
Ventilated, n (%)	154 (55.40)
Oliguria (n = 226), n (%)	101 (44.69)
Initial coma, n (%)	94 (33.81)
Cr (mg/dl), median (IQR1, IQR3)	1.4 (0.9, 2.8)
ROSC, n (%)	156 (56.12)
Survival at hospital discharge, n (%)	72 (25.90)
Survival at seven days post discharge, n (%)	54 (19.42)
Morbidity scores (n = 192), median (IQR1, IQR3)	
PAM score	5 (3, 7)
MPI score	5 (3, 6.5)
PAR score	3 (0, 5)

IQR = inter-quartile range; IHCA = in-hospital cardiac arrest; ICU = intensive care unit; LOS = length of stay; PEA = pulseless electrical activity; VF = ventricular fibrillation; VT = ventricular tachycardia; DM = diabetes mellitus; HT = hypertension; MI = myocardial infarction; ROSC = return of spontaneous circulation; PAM score = pre-arrest morbidity score; MPI = modified PAM index score; PAR = prognosis after resuscitation score

Based on this analysis, PAM and MPI scores performed similarly, and both were better at predicting mortality than PAR. Table 3 and 4 represent test characteristics at different cutoff points for PAM and

Table 2. The overall performance of the three morbidity scores by type using AUC of ROC curves

Types	PAM, AUC (95% CI)	MPI, AUC (95% CI)	PAR, AUC (95% CI)	*p*-value
IHCA	0.62 (0.51 to 0.73)	0.63 (0.52 to 0.73)	0.60 (0.49 to 0.71)	0.89
OHCA	0.76 (0.58 to 0.95)	0.75 (0.56 to 0.94)	0.56 (0.38 to 0.74)	<0.05

IHCA = in-hospital cardiac arrest; OHCA = out-hospital cardiac arrest; ROC curve = receiver operating characteristic curve; AUC = area under ROC curve; CI = confidence interval; PAM score = pre-arrest morbidity score; MPI = modified PAM index score; PAR = prognosis after resuscitation score
p-value was significant at $p<0.05$

Table 3. The performance of the PAM score to predict death at seven days after discharge based on ROC curve analysis

Cutpoint	Sensitivity (%)	Specificity (%)	PPV	NPV	LR+	LR-	AUC	Youden's index
≥2	86.8	26.8	81.4	35.5	1.12	0.49	0.57	0.14
≥3	80.8	31.7	81.3	31.0	1.18	0.61	0.56	0.13
≥4	72.2	41.5	82.0	28.8	1.23	0.67	0.57	0.14
≥5	59.6	63.4	85.7	29.9	1.63	0.64	0.62	0.23
≥6	49.0	80.5	90.2	30.0	2.51	0.63	0.65	0.30
≥7	39.1	87.8	92.2	28.1	3.20	0.69	0.63	0.27

PPV = positive predictive value; NPV = negative predictive value; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; ROC curve = receiver operating characteristic curve; AUC = area under the ROC curve; PAM score = pre-arrest morbidity score

Table 4. The performance of the MPI score to predict death at seven days after discharge based on ROC curve analysis

Cutpoint	Sensitivity (%)	Specificity (%)	PPV	NPV	LR+	LR-	AUC	Youden's index
≥2	88.1	22.0	80.6	33.3	1.13	0.54	0.55	0.10
≥3	80.1	41.5	83.4	36.3	1.37	0.48	0.61	0.22
≥4	66.9	51.2	83.5	29.6	1.37	0.65	0.59	0.18
≥5	57.0	73.2	88.7	31.6	2.12	0.59	0.65	0.30
≥6	45.7	80.5	89.6	28.7	2.34	0.68	0.63	0.26

PPV = positive predictive value; NPV = negative predictive value; LR+ = positive likelihood ratio; LR- = negative likelihood ratio; ROC curve = receiver operating characteristic curve; AUC = area under the ROC curve; MPI = modified PAM index score

MPI. The optimal cutoff point to predict death was ≥6 for PAM and ≥5 for MPI.

Discussion

The results from the present study are consistent with those of previous reports in that any one of the three morbidity scores (PAM, MPI, and PAR) were found to be insufficient to be used as the sole tool to predict survival after CPR[17,21]. The overall performances of these scores did not differ according to the area under the ROC curve. In a previous study, the area under the ROC curve of PAR was found to be significantly higher than that under the PAM index curve for IHCA[20], which contrasts with the results of the present study. This difference is probably explained by the study population. The previous study was conducted in an older population, with a mean age of 70 years old (the mean age in our study was about 58 years old). Age ≥70 years old is one of the clinical characteristics included in the PAR score, where it is not included in the PAM score. The PAR score, thus, performed better in than the PAM score in that study. In cases of OHCA, PAM and MPI scores performed better overall than in cases of IHCA and significantly better than the PAR score. Due to the small number of patients with OHCA, and all three morbidity scores being studied mainly in patients with IHCA[17,23-25], these results may be open to interpretation.

In the present study, PAM and MPI scores demonstrated low sensitivity, high specificity, and positive predictive value, which is consistent with the results of prior studies[17,21]. This may be explained by the fact that other predictors of morbidity, such as pre-arrest cardiac rhythm, quality of CPR and delay of initiation of CPR, were not included in the three morbidity scores examined here[15,17,26]. In terms of applicability, most patients with high morbidity scores did not survive. However, this did not mean that patients with lower scores would survive due to the low sensitivity of these scores[17]. Thus, while these scores should not be used as the main guidelines as to whether or not to perform CPR in patients with low scores, they are useful in identifying patients with a high risk of failing to survive after CPR[21]. A PAM

score >6 and an MPI score >5 were optimal cutoff values to identify patients with increased potential for mortality at discharge following CPR. Prior reports have shown these PAM cutoff points to have higher specificity (>90%) and lower sensitivity (20% to 30%), but no data are available regarding MPI values[17,24]. A possible explanation for these differences is the study setting, as DNR policies vary by locale and might affect the outcomes[17,24].

Multifactorial tools are required to predict survival at hospital discharge after CPR as overall performances of the existing morbidity scores are limited. Adverse outcomes of CPR among survivors with prolonged hypoxemia are related to reduced function and cognition, burdening caregivers and leading to decreased quality of life for patients[16]. Accordingly, the authors recommend incorporating other factors and developing better fit models in order to avoid futile resuscitation[3,14,16,27].

The present study is limited in certain respects. First, the study was conducted in a single tertiary-care institution in which equipment and trained staff were available and thus, may not be generalizable to other settings. Second, due to the retrospective nature of the study design, some of the medical records contained incomplete data. Third, due to the small number of patients with OHCA, one should be cautious when attempting to interpret these results.

Conclusion

PAM, MPI, and PAR scores all performed similarly poorly in predicting death at hospital discharge in cardiac arrest patients who received CPR. PAM and MPI scores appear to have performed better among patients with OHCA. It is recommended that all three morbidity scores be used in conjunction to predict patient outcomes and that their application in clinical practice should be interpreted cautiously. Development of novel predictive models is recommended.

What is already known on the topic?

The PAM score, the PAR score, and the MPI have been developed to predict morbidity in cardiac arrest patients. They could be used as part of the decision-making process regarding DNR orders in patients with cardiac arrest. There are limited data about their applicability of those scores in Thailand.

What this study adds?

PAM, MPI, and PAR scores are not sufficient tools to identify Thai patients who would benefit from resuscitation attempts among patients. They should be used as additional tools for decision making in whom CPR is likely to be unsuccessful due to their high specificities.

Acknowledgment

The authors would like to acknowledge Dylan Southard (Research Affairs, Faculty of Medicine, Khon Kaen University, Thailand) for editing the manuscript. This manuscript was funded by the Neuroscience Research and Development Group (Khon Kaen University, Thailand) under grant number 001/2558, Sleep Apnea Research Group (Khon Kaen University, Thailand) and the Thailand Research Fund (number IRG 5780016).

Potential conflicts of interest

The authors declare no conflict of interest.

References

1. Song W, Chen S, Liu YS, He NN, Mo DF, Lan BQ, et al. A prospective investigation into the epidemiology of in-hospital cardiopulmonary resuscitation using the international Utstein reporting style. Hong Kong J Emerg Med 2011; 18:391-6.
2. Bloom HL, Shukrullah I, Cuellar JR, Lloyd MS, Dudley SC Jr, Zafari AM. Long-term survival after successful inhospital cardiac arrest resuscitation. Am Heart J 2007;153:831-6.
3. Limpawattana P, Siriussawakul A, Chandavimol M, Sawanyawisuth K, Chindaprasirt J, Senthong V, et al. National data of CPR procedures performed on hospitalized Thai older population patient. Int J Gerontol 2015;9:67-70.
4. Alabi TO, Haines CA. Predicting survival from in-hospital CPR. Clin Geriatr 2009;17:34-6.
5. Ebell MH, Becker LA, Barry HC, Hagen M. Survival after in-hospital cardiopulmonary resuscitation. A meta-analysis. J Gen Intern Med 1998;13:805-16.
6. Lidhoo P. Evaluating the effectiveness of CPR for in-hospital cardiac arrest. Am J Hosp Palliat Care 2013;30:279-82.
7. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes 2010;3:63-81.
8. Fredriksson M, Aune S, Thoren AB, Herlitz J. In-hospital cardiac arrest--an Utstein style report of seven years experience from the Sahlgrenska

University Hospital. Resuscitation 2006;68:351-8.
9. Krittayaphong R, Saengsung P, Chawaruechai T, Yindeengam A, Udompunturak S. Factors predicting outcome of cardiopulmonary resuscitation in a developing country: the Siriraj cardiopulmonary resuscitation registry. J Med Assoc Thai 2009;92:618-23.
10. Kutsogiannis DJ, Bagshaw SM, Laing B, Brindley PG. Predictors of survival after cardiac or respiratory arrest in critical care units. CMAJ 2011;183:1589-95.
11. Kanoupakis EM. In-hospital cardiac arrest. Hosp Chron 2012;7:77-80.
12. Suraseranivongse S, Chawaruechai T, Saengsung P, Komoltri C. Outcome of cardiopulmonary resuscitation in a 2300-bed hospital in a developing country. Resuscitation 2006;71:188-93.
13. Chan JC, Wong TW, Graham CA. Factors associated with survival after in-hospital cardiac arrest in Hong Kong. Am J Emerg Med 2013;31:883-5.
14. Ebell MH, Afonso AM. Pre-arrest predictors of failure to survive after in-hospital cardiopulmonary resuscitation: a meta-analysis. Fam Pract 2011;28: 505-15.
15. Sandroni C, Nolan J, Cavallaro F, Antonelli M. In-hospital cardiac arrest: incidence, prognosis and possible measures to improve survival. Intensive Care Med 2007;33:237-45.
16. Chang WH, Huang CH, Chien DK, Su YJ, Lin PC, Tsai CH. Factors analysis of cardiopulmonary resuscitation outcomes in the elderly in Taiwan. Int J Gerontol 2009;3:16-25.
17. Bowker L, Stewart K. Predicting unsuccessful cardiopulmonary resuscitation (CPR): a comparison of three morbidity scores. Resuscitation 1999;40: 89-95.
18. Cohn EB, Lefevre F, Yarnold PR, Arron MJ, Martin GJ. Predicting survival from in-hospital CPR: meta-analysis and validation of a prediction model. J Gen Intern Med 1993;8:347-53.
19. Ebell MH, Jang W, Shen Y, Geocadin RG. Development and validation of the Good Outcome Following Attempted Resuscitation (GO-FAR) score to predict neurologically intact survival after in-hospital cardiopulmonary resuscitation. JAMA Intern Med 2013;173:1872-8.
20. O'Keeffe S, Ebell MH. Prediction of failure to survive following in-hospital cardiopulmonary resuscitation: comparison of two predictive instruments. Resuscitation 1994;28:21-5.
21. Ohlsson MA, Kennedy LM, Juhlin T, Melander O. Evaluation of pre-arrest morbidity score and prognosis after resuscitation score and other clinical variables associated with in-hospital cardiac arrest in southern Sweden. Resuscitation 2014;85:1370-4.
22. Hanley JA, McNeil BJ. A method of comparing the areas under receiver operating characteristic curves derived from the same cases. Radiology 1983;148:839-43.
23. George AL Jr, Folk BP 3rd, Crecelius PL, Campbell WB. Pre-arrest morbidity and other correlates of survival after in-hospital cardiopulmonary arrest. Am J Med 1989;87:28-34.
24. Dautzenberg PL, Broekman TC, Hooyer C, Schonwetter RS, Duursma SA. Review: patient-related predictors of cardiopulmonary resuscitation of hospitalized patients. Age Ageing 1993;22: 464-75.
25. Ebell MH. Prearrest predictors of survival following in-hospital cardiopulmonary resuscitation: a meta-analysis. J Fam Pract 1992;34:551-8.
26. Brindley PG, Markland DM, Mayers I, Kutsogiannis DJ. Predictors of survival following in-hospital adult cardiopulmonary resuscitation. CMAJ 2002; 167:343-8.
27. Mohr M, Kettler D. Ethical aspects of resuscitation. Br J Anaesth 1997;79:253-9.