Neuroanesthesia and Intensive Care

Transthoracic echocardiography does not improve prediction of outcome over APACHE II in medical-surgical intensive care

[L'échocardiographie transthoracique n'améliore pas la prédiction des résultats par rapport au score APACHE II à l'unité des soins intensifs médicaux chirurgicaux]

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Purpose: To examine the hypothesis that transthoracic echocardiographic findings predict mortality in critically ill patients.

Methods: A retrospective analysis of concurrently collected data for consecutive patients from May 1996 to May 1998 who had transthoracic echocardiography on or within six months of admission to the medical surgical intensive care (MSICU). We examined the role of physiologic, clinical, and echocardiography variables in predicting the mortality of patients admitted to the MSICU. Three logistic regression models were developed: 1) clinical; 2) echocardiographic; and 3) combined clinical with echocardiographic. Univariate and multivariate analyses were performed and the relative strength of clinical and echocardiographic predictors was compared using odds ratio (OR) and receiver-operator-characteristic (ROC).

Results: Of 4,070 MSICU patient admissions, 1,093 patients had transthoracic echocardiography; the study group comprised 942 patients with complete clinical and echocardiographic data. The MSICU mortality was 28%. For the combined model, analyses identified left ventricular systolic function (LVSF), {OR 1.26; confidence interval (CI) 1.01–1.57}, severe tricuspid regurgitation (TR) (OR 3.72; CI 1.04–13.24), medical diagnosis (OR 1.91; CI 1.15–3.19), and acute physiology and chronic health evaluation (APACHE) II score (OR 1.27; CI 1.23–1.31), as predictors of MSICU mortality. The combined model yielded an area under ROC curve of 0.913. For the clinical model, analyses identified age (OR 1.04; CI 1.02–1.05) and APACHE II (OR 1.32; 1.26–1.35) as predictors of mortality with an area under ROC curve of 0.917. For the echocardiography model, TR (OR 2.40; 1.08–5.38), severe aortic insufficiency (AI) (OR 4.13; CI 1.17–16.29) and pulmonary hypertension (OR 2.05; 1.01–4.09) were identified as predictors of outcome with an ROC curve of 0.536 for this model.

Conclusion: Statistical models utilizing clinical variables are predictive of mortality in MSICU. Models that include diagnostic transthoracic echocardiography variables do not provide incremental value to predict ICU mortality. These findings may have implications for non-invasive hemodynamic assessment of critically ill patients, and raise the hypothesis that echocardiography-guided interventions may not alter outcome in ICU.

Objectif : *Vérifier l'hypothèse selon laquelle les résultats de l'échocardiographie transthoracique permettent de prédire la mortalité chez les grands malades.*

Méthode : *Une analyse rétrospective a été faite des données recueillies simultanément auprès de patients successifs qui ont eu, entre mai 1996 et mai 1998, une échographie transthoracique six mois ou moins après l'admission à l'unité des soins intensifs médicaux chirurgicaux (USIMC). Nous avons vérifié le rôle des variables physiologiques, cliniques et échocardiographiques dans la prédiction de la mortalité à l'USIMC. Trois modèles de régression logistique ont été élaborés : clinique, échocardiographique, et clinique et échocardiographique combiné. Des analyses à une ou plusieurs variables ont été réalisées et la valeur relative des prédicteurs cliniques et échocardiographiques a été comparée selon le risque relatif (RR) et la courbe ROC.*

Résultats : *Des 4 070 patients admis à l'USIMC, 1 093 ont eu une échocardiographie transthoracique ; le groupe expérimental comprenait 942 patients dont nous avions les données cliniques et échocar-*

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Presented as abstract at the American Society of Anesthesiology Annual Meeting, Dallas, TX, USA, October 1999.
Supported by: The Department of Anesthesia, University Health Network, University of Toronto. Toronto, Ontario, Canada.
Accepted for publication July 16, 2002.
Revision accepted November 13, 2002.

diographiques complètes. La mortalité à l'USIMC a été de 28 %. Pour le modèle combiné, la fonction systolique du ventricule gauche (FSVG), {RR de 1,26, intervalle de confiance (IC) de 1,01-1,57}, la régurgitation tricuspide (RT) sévère (RR de 3,72 ; IC de 1,04-13,24), le diagnostic médical (RR de 1,91 ; IC de 1,15-3,19) et le score APACHE II (RR de 1,27 ; CI de 1,23-1,31) ont été des prédicteurs de mortalité à l'USIMC. Ce modèle présentait une aire sous la courbe ROC de 0,913. Pour le modèle clinique, l'âge (RR de 1,04 ; IC de 1,02-1,05) et le score APACHE II (RR de 1,32 ; 1,26-,35) ont été des prédicteurs de mortalité avec une aire sous la courbe de 0,917. Pour le modèle échocardiographique, la RT (RR de 2,40 ; 1,08-5,38), l'insuffisance aortique sévère (IA) (RR de 4,13 ; CI de 1,17-16,29) et l'hypertension pulmonaire (RR de 2,05 ; 1,01-4,09) ont été des prédicteurs avec une aire sous la courbe de 0,536.

Conclusion : *Les modèles statistiques utilisant des variables cliniques sont prédictifs de mortalité à l'USIMC. Les modèles incluant les variables diagnostiques de l'échocardiographie transthoracique n'améliore pas la prédiction de la mortalité à l'USI. Ces résultats peuvent influencer l'évaluation hémodynamique non effractive des grands malades et donner à penser que des interventions guidées par échocardiographie ne modifient pas l'évolution à l'USI.*

PREDICTORS of outcome in critical care are well described and include clinical, diagnostic, and physiologic variables.[1] The acute physiology and chronic health evaluation (APACHE) II scoring system is commonly used in the medical and surgical intensive care (MSICU) population to prognosticate outcome, and to compare acuity of medical care in different intensive care units.[2] The APACHE II scoring system is not meant to prognosticate outcome in the coronary care population or following cardiac surgery.

Transthoracic echocardiography (TTE) is a widely recognized non-invasive clinical tool in the assessment of patients with cardiovascular disease. The clinical impact of TTE on the daily bedside medical management decisions for patients in medical ICU has been previously described.[3–5] TTE diagnostic variables have been shown in the past to be predictive of mortality in non-critical care cardiovascular patients with diastolic dysfunction.[6] However, the association of TTE diagnostic variables with outcome in MSICU remains unclear.

The purpose of our study was to assess the utility of clinical and transthoracic diagnostic echocardiography variables in predicting mortality in the MSICU population.

Material and methods

Following approval of the University Health Network (UHN) Ethics Committee, we performed a linkage of the MSICU and echocardiographic laboratory database to identify all patients admitted to the MSICU from May 1996 to May 1998 and who also underwent TTE. The UHN MSICU patient population included a broad range of adult patients consisting of general medical and surgical patients. Coronary care and cardiac surgical patients received care at separate critical care units. A dedicated medical assistant prospectively recorded clinical and outcome data from all MSICU patients; these data (including the APACHE II score) were entered into the MSICU database.

All patients scheduled for TTE underwent comprehensive evaluation of valves, ventricular function, and systolic pulmonary artery pressures. Imaging and Doppler data were reviewed by cardiologists with level III expertise in echocardiography. Data from each clinical study were entered into the database by certified sonographers.

Medical record numbers of patients from the echocardiography database identified as having echocardiograms in the MSICU or within six months of admission to MSICU were cross-referenced to the MSICU database to obtain their demographics, APACHE II diagnosis, and APACHE II scores and outcome data. Echocardiogram reports from the study population were reviewed for specific abnormalities.

Data from the echocardiography database were extracted by performing a query requesting appropriate diagnostic codes for the individual patients. Echocardiography diagnostic variables identified as potential predictors of mortality were accessed from the echocardiography database for the defined patient population. Potential predictors of outcome were defined prior to data analyses. These variables included severe stenotic or regurgitant heart valve lesions, elevated pulmonary artery pressures (> 35 mmHg) and left ventricular systolic function (LVSF) defined by a standard grading system.[7–12] The ejection fraction (EF) corresponding to Grades I–IV left ventricular function were as follows; Grade I > 60%, Grade II 40–59%, Grade III 20–39%, Grade IV < 20%. Primary outcome for the study was defined as ICU mortality.

Clinical and echocardiographic data were entered into a database (Microsoft Excel 97, Redmond, WA, USA) and statistical analyses were performed (SPSSS Inc. version 10.0.7 Chicago IL, USA). For the purpose of the analyses, LVSF was treated as a categoric variable graded I, II, III, IV. Three statistical models were developed to predict mortality: 1) clinical variables; 2) echocardiographic variables; and 3) combined clinical with echocardiographic variables. For each model, univariate analyses were performed to identify variables associated with mortality. For poten-

TABLE I Demographic data

Variable	*n (%)*
Age > 70	378 (40)
Gender M:F	532:410
ICU readmissions	48 (5)
Emergency surgery	129 (32)
Admitting medical diagnosis	448 (48)
Admitting surgical diagnosis	494 (52)
ICU mortality	265 (28.1)

ICU = intensive care unit.

TABLE II Echocardiographic data

Variable	*n (%)*
Grade I: LVEF > 60%	464 (49)
Grade II: LVEF 40–59%	283 (30)
Grade III: LVEF 20–39%	145 (15)
Grade IV: LVEF< 20%	50 (5)
RV systolic dysfunction	79 (8)
Severe MR	45 (5)
Severe TR	26 (0.6)
Severe AI	10 (1)
Pulmonary hypertension	35 (4)

LVEF = left ventricular ejection fraction; RV = right ventricular; MR = mitral regurgitation; TR = tricuspid regurgitation; AI = aortic insufficiency.

tial predictor variables which were continuous, t test was used. For predictors that were categorical, Chi-square was utilized. All predictors with a *P* value of < 0.10 were entered into multivariate logistic regression model using a stepwise backwards elimination algorithm. If two univariate predictors were closely correlated variables (R > 0.70), then the predictor with the most significant relationship to the outcome were entered into the multivariate model. The level of significance of < 0.05 (two sided) was considered significant. The odds ratio (OR), 95% confidence interval (CI) and *P* values were presented for each identified independent predictor. The discriminative accuracy of clinical, echocardiographic, and combined models was expressed as the area under the ROC curve.

Results

Of 4,070 MSICU patient admissions between 1996 and 1998, 1,093 patients had echocardiograms. Data on 942 patients were complete and utilized for analyses. The mean age of the population was 62 ± 16 (range 17–97) yr. The mean APACHE-II score was 18 ± 9 (range 0–49) and the MSICU mortality was 28%. The distribution of admission diagnoses into MSICU for the study population is described in the

TABLE III Univariate predictors of ICU mortality

Variable	*OR*	*95% confidence interval*	*P value*
Age > 70 yr	1.36	1.01–1.83	0.04
ICU readmission	1.79	0.98–3.27	0.05
Emergency surgery	2.22	1.35–3.57	0.01
Medical admission	6.37	4.28–9.50	0.001
APACHE II	1.28	1.24–1.32	0.0001
Severe TR	2.63	1.20–5.75	0.01
Severe AI	3.89	1.09–13.89	0.02
Pulmonary hypertension	2.23	1.13–4.41	0.02

OR = odds ratio; ICU = intensive care unit. APACHE = acute physiology and chronic health evaluation; TR = tricuspid regurgitation; AI = aortic insufficiency.

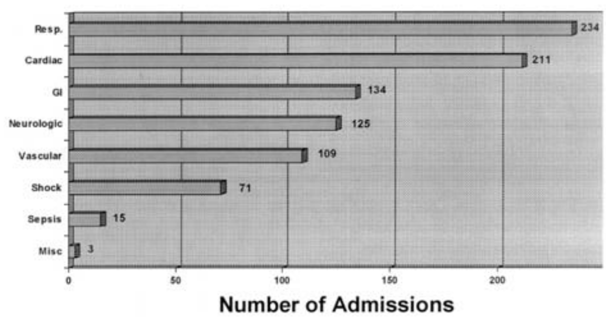

FIGURE Distribution of admission diagnosis. RESP = respiratory; GI = gastro-intestinal; MISC = miscellaneous.

Figure, with the most common admission diagnoses being respiratory failure, cardiac disease, neurologic dysfunction and gastrointestinal disorders. Forty percent of the patients were over the age of 70, (Table I) and 50% of the patients had at least mild left ventricular systolic dysfunction (Table II). The proportion of patients with other echocardiographic findings is outlined in Table II.

Univariate analyses showed LVSF, severe tricuspid regurgitation (TR), severe aortic insufficiency (AI), pulmonary hypertension, age, APACHE II score, and admitting diagnosis to be associated with mortality (Table III). For the clinical model, logistic regression analyses identified age (OR 1.04; CI 1.05–1.03) and APACHE II (OR 1.32; CI 1.26–1.35) as predictors of outcome with an area under ROC curve of 0.917 (Table IV). For the echocardiography model, severe TR (OR 2.40; CI 1.08–5.38), severe AI (OR 4.1; CI 1.71–16.29) or pulmonary hypertension (OR 2.05; CI

TABLE IV Logistic regression models

Model	*Variable*	*OR*	*95% confidence interval*	*P value*
Echocardiographic and clinical				
	LVSF I:II:III:IV	1.26	1.01–1.57	0.04
	Severe TR	3.72	1.04–13.24	0.04
	Medical diagnosis	1.90	1.15–3.19	0.01
	APACHE II score	1.27	1.23–1.31	0.0001
Clinical				
	Age	1.04	1.02–1.05	0.0001
	APACHE II	1.30	1.26–1.35	0.0001
Echocardiographic				
	Severe TR	2.41	1.08–5.38	0.03
	Severe AI	4.13	1.17–16.29	0.03
	Pulmonary hypertension	2.05	1.01–4.09	0.04

OR = odds ratio; LVSF = left ventricular systolic function; TR = tricuspid regurgitation; APACHE = acute physiologic and chronic health evaluation; AI = aortic insufficiency.

TABLE V Comparison of logistic regression models

Model	ROC curve
Echocardiography	0.536
Clinical	0.917
Combined clinical and echocardiography	0.913

ROC = receiver-operator-characteristic.

1.01–4.09) were identified as predictors of outcome with area under ROC curve of 0.54 for this model (Table IV). For the combined model, logistic regression analyses identified LVSF (OR 1.26, CI 1.01–1.57), TR (OR 3.72, CI 1.04–13.24), medical *vs* surgical diagnosis (OR 1.91, CI 1.16–3.19), and APACHE II (OR 1.27, CI 1.23–1.31) as predictors of outcome with an area under ROC curve of 0.913 (Table IV). Comparing the area under the ROC curves, there were no significant differences between the combined and clinical models (Table V). Indeed, the area under the ROC curves for the echocardiography model was less than the combined and clinical models.

Discussion

The APACHE prognostic scoring system is a powerful predictor of hospital mortality in the MSICU patient population, both in North America[13,14] and internationally.[15–18] Our objective was to determine, in a large number of patients, if echocardiographic data would add prognostication to existing clinical variables in MSICU patients. This clinical study attempts to associate specific cardiovascular pathology identified utilizing TTE with mortality in the MSICU. Our study clearly demonstrates that standard clinical parameters are predictive of mortality in the MSICU and that specific diagnostic echocardiography variables do not add further predictive value to current outcome models.

Our study population is a mixed medical surgical population with multiple medical problems and may not be applicable to coronary care or cardiovascular intensive care patients. Previous studies utilizing TEE diagnostic applications in ICU patients with sepsis, unexplained hypoxemia, shock states, trauma, aortic dissection, and hemodynamic instability have been described.[19–21] TEE has been shown to be an appropriate means to estimate cardiovascular hemodynamics including atrial pressure, ventricular filling and cardiac output.[22–27] TEE is also a sensitive indicator of myocardial ischemia and is advocated for the routine monitoring of high risk cardiac surgery patients.[28,29] In one small study in critically ill patients with unexplained hypotension TEE diagnostic variables were shown to predict mortality.[30] A recent study also highlighted the utility of TEE in assisting management strategies in 58% of postoperative cardiac surgical patients who had TEE.[31] A secondary finding was a lower associated mortality in patients having a surgical intervention as a result of the TEE diagnosis. Our study differs significantly from this previous study as we examined the role of TTE in predicting mortality in a much larger group of patients admitted to the MSICU. A large prospective study examining the diagnostic and prognostic role of TTE and TEE in MSICU patients has yet to be performed.

Limitations of this clinical study include its retrospective nature. Entry into the study was defined by both MSICU admission and recent TTE; the study findings can only be generalized to those MSICU patients who required echocardiographic assessment. Not all patients in our study group underwent echocardiography on initial admission to the MSICU.

Therefore, some echocardiographic variables may have changed between the time of TTE and MSICU admission. This study may have underestimated hospital mortality as we studied MSICU mortality only. In addition, our study assessed the diagnostic data obtained by echocardiography; specific hemodynamic variables such as cardiac output or diastolic function were not obtained. It is not known whether specific clinical interventions were initiated based on the TTE findings that may have influenced outcome.

The utility of advanced technology such as echocardiography and hemodynamic monitoring with Swan-Ganz catheters are part of the routine clinical tools available to the intensive care physician. Despite the proposed advantages of these clinical diagnostic and monitoring tools, the benefits of these technologies on clinical outcome remain unproven.[32] Limitations to the routine implementation of echocardiography to assess the cardiovascular status of the critically ill exist. Limitations to its widespread utility in the MSICU exist secondary to the complexity and severity of illness that inhibit access to good acoustic windows in approximately 30% of patients who have TTE.[33] TEE imaging overcomes these imaging difficulties because the proximity of the esophagus to the cardiac structures provides good acoustic windows. However TEE is more invasive, associated with more complications, and requires the presence of a trained physician to perform the test thus limiting access to the technology.[34,35] Other limitations to routine utilization of echocardiography in critical care include high capital costs of equipment, appropriate training of critical care physicians and the time commitment to perform routine examinations in all patients. Our data do not support routine TTE in all MSICU patients. The current results may underestimate the potential utility of echocardiography in the ICU. The examinations were not undertaken in the context of dynamic trials of, for example, altered loading conditions or inotrope titration at the patient's bedside. The potential benefits of routine bedside hemodynamic assessment utilizing TTE in the MSICU were not addressed by our study.

In conclusion, statistical models utilizing clinical variables are predictive of mortality in the MSICU. Models that include diagnostic echocardiography do not provide incremental value to predict MSICU mortality.

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