# Comparison of risk scoring systems in congenital heart surgery

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**SUMMARY: Sabuncu T, Demircin M, Doğan R, Yılmaz M, Aypar U, Paşaoğlu İ. Comparison of risk scoring systems in congenital heart surgery. Turk J Pediatr 2016; 58: 512-517.**

**Hacettepe University Faculty of Medicine Department of Cardiovascular Surgery; data of 413 patients under 18 years old who had congenital heart surgery were evaluated between 01.01.2011-30.10.2012 and risk scorings were made by "RACHS-1 (Risk Adjustment in Congenital Heart Surgery)", "Aristotle Basic Complexity Score (ABS)" and "Aristotle Comprehensive Complexity Score (ACS)" systems used in evaluation of the risk of mortality and morbidity in congenital heart surgery. Data obtained were compared by Mann-Whitney U test and how effective these systems were in evaluating mortality and morbidity and their superiorities over each other were examined. Following the research, it was observed that all three systems were effective in evaluating mortality and morbidity; the most successful of them in foreseeing the event was the ACS system, ACS system was followed by RACHS-1 system and ABS system was the most incapable of these in foreseeing the event. It was seen that in detecting time related mortality, rating of these tests changed, RACHS-1 system detected the time related mortality best. It was also seen that with RACHS-1 system, a previously evaluated concept, it was possible to determine morbidity.**

***Key words: congenital heart surgery, pediatric cardiac surgery, risk evaluation, RACHS-1, ABS, ACS.***

Various strategies, lists, study groups were formed to determine mortality and morbidity in heart diseases to led the cardiologists and cardiac surgeons to determine which patient would benefit from surgical intervention.

These systems have been used regularly for adult patients from past to present, various risk classification systems have been developed (Initial Parsonnet Score, Cleveland Clinic Score, EuroSCORE etc.). In 2000, a comprehensive study comparing 6 separate risk scoring systems for adult patients was conducted in Germany[1]. But in congenital heart surgery, such systems have not been established, or they are not used commonly worldwide. One of the most important reasons of this is that there are too many different anatomical diagnoses and surgical procedures in congenital heart diseases[2].

This study, planned to research how effective the congenital heart surgery risk evaluation systems "RACHS-1 (Risk Adjustment in Congenital Heart Surgery)", "Aristotle Basic Complexity Score (ABS)" and "Aristotle Comprehensive Complexity Score (ACS)" are in determining morbidity and mortality of congenital heart surgery patients and whether it can be used in the same way as it is used with the adult cardiac surgery candidate patients to determine the prognosis of these patients and to compare the effectiveness of these systems.

## General Information

*RACHS-1 Scoring System*

Studies regarding this system started in 1997. A team of pediatric cardiologists and cardiovascular surgeons tried by consensus to

create a system that would be easy enough to be used commonly, yet effective enough to predict. The aim in this study was to be able to foresee the short term mortality of congenital heart surgery in patients under age 18[2]. Morbidity was not a concept aimed at evaluating[3].

In this scoring system not a certain division is used regarding the surgical technique, similarly, additional procedures implemented are not taken into consideration. If the patients will have more than one surgical procedure, the procedure with the highest risk category is taken into consideration[4].

*Aristotle Basic Scoring System*

The study for this scoring system was started in 1999 with the participation of the surgeons representing European Association of Cardiothoracic Surgeons (EACTS), Society of Thoracic Surgeons (STS), European Congenital Heart Surgery Association (ECHSA) and Congenital Heart Surgeons Society (CHSS)[5-7].

In 1999, STS and EACTS started the nomenclature study in heart surgery[6]. These data bases have been frequently updated with the studies conducted[8,9].

Because there were approximately 150 surgical procedures and about 200 anatomic diagnoses, conducting a complex study was needed to evaluate success in congenital heart surgery[5]. Difficulty levels of surgical procedures were estimated considering only the procedure itself, not considering the anatomical diagnose[5]. This kind of a scoring was preferred because the same operation could be implemented in more than one anatomical diagnosis. Complexity was constituted by the aggregation of 3 factor: 1. In hospital mortality potential 2. Postoperative morbidity (stay in Intensive Care Unit) 3. Technical difficulty of the surgical procedure. Each category was divided into 5 levels according to the score it got (Table I).

Scoring in ABS system varies between 1.5 and 15 and there are 4 difficulty levels (1.5-5.9=1. level, 6.0-7.9=2. level, 8.0-9.9=3. level, 10.0-15.0=4. level). 145 procedures included in the ABS system.

In this scoring system, factors that could cause mortality weren't included in scoring directly, either. Yet, differently from RACHS system, morbidity (morbidity bound only to procedure) took part in the scoring by taking the stay in intensive care unit into consideration.

*Aristotle Comprehensive Scoring System*

Aristotle Comprehensive Scoring (ACS) system is a system constituted upon ABS system. In this system, factors about the patient are also included in the scoring system[5]. These factors are divided into two groups as factors related to the procedure and factors not related to the procedure.

Comprehensive scoring system consists of the aggregation of ABS system and scores of the factors about the patient. In ABS system, the highest score of 15 is increased to 25, the complexity degree is increased from 4 to 6 (15.1-20.0=5. level, 20.1-25.0=6. level)[5]. In ACS system, scores to be added to the ABS score is maximum 5.0 points for each group (factors about the procedure and factors about the patient) and highest total score that can be added to ABS is 10.0 points.

In ACS system, factors that are not related to the surgical procedure to be implemented and the factors the patient had previously and that can affect the mortality and morbidity possibility of the patient independently from the operation are included in the scoring. Also in ACS system, some factors related to the procedure are included in the scoring differently from ABS and RACHS systems. For example, some risk factors specific to the procedure such as existence of coronary anomaly in the arterial switch operations are scored in ACS system.

## Material and Methods

*Patient Selection*

Hospital data of 413 patients under the age of 18 who was operated between 01.01.2011-30.10.2012 at Hacettepe University Faculty of Medicine, Department of Thoracic-Cardiovascular Surgery were evaluated and desired information was obtained in scoring systems.

There were 32 patients to whom procedures included in scoring in ABS and ACS systems, but not included in RACHS system. These procedures consisted of cardiac transplantation, sternal contusion debridement, pacemaker/ICD implantation or change, lobectomy and lung biopsies. These patients were not excluded from

the study to see how effective these procedures generally, not solitarily with RACHS system were in determining mortality and morbidity in cardiovascular surgery intensive care.

*Method*

Patient information was scanned retrospectively from hospital records and apart from the data of patients defined in the forms for scoring, operation dates, arrival dates to intensive care and departure dates from intensive care, exitus dates if the patient deceased were recorded.

The obtained data was entered in the forms, collected from the previous studies[3,5]. In ACS system, the "Aristotle Institute" official web site was used for "factors about the procedure" and scores obtained from here and causes of the scores were recorded separately for each patient on forms.

While mortality was defined as the patient's deceasing after operation before discharge from hospital or deceasing after hospital discharge within 30 postoperative days, morbidity was defined as the patient's requiring intensive care longer than postoperative 48 hours.

Mann-Whitney U test was used to statistically analyze the obtained data. ROC (Receiver Operating Characteristic) curves and time related ROC curves were formed and superiorities of the systems over each other were evaluated.

## Results

*Mortality*

When the obtained data were evaluated, 53 of 413 patients were observed to develop mortality. Only one of these patients deceased after a procedure not included in the RACHS system (pacemaker implantation due to congenital A-V full block). In another 31 patients whom procedures were not included in RACHS system (18 patients to whom pacemaker implantation or change was implemented, 5 patients to whom lung operation was implemented, 4 patients to whom pericardial drainage was implemented, 2 patients to whom cardiac transplantation was implemented and 2 patients to whom sternal contusion debridement was implemented), no mortality was observed.

When descriptive statistics were examined, 329 of 381 patients evaluated by RACHS system survived. Average RACHS score of these patients was determined as 2.0365, for deceased patients, average score was determined as 3.2692.

All patients included in the study (N=413) were evaluated by ABS system. 53 of these patients developed mortality. When the statistics of the alive patients analyzed, it was seen that average ABS score was 5.9225. When deceased patients (N=53) were evaluated by ABS system, average ABS score was 8.6132.

All patients included in the study (N=413) were also evaluated by ACS system. Mortality numbers (N=53) were the same as in the ABS system. The statistics of 360 alive patients, it was seen that the average ACS score was 7.6419. The 53 deceased patients' average ACS score was 14.2396.

When RACHS, ABS and ACS scores of the alive and deceased patients were compared by Mann Whitney U test, all three scores were found to be meaningfully high among deceased patients (P=0.001). It was observed that in this case, ACS system could foresee the mortality in the sharpest way (Z=-9.102), RACHS system followed this (Z=-7.782) and ABS system was the least accurate system in these scoring systems (Z=-6.557).

**Table I.** Degree of Complexity in the ABS System. Complexity of Degree Consists of the Aggregation of Mortality, Morbidity and Technical Difficulty[5].

| Complexity Level | Mortality (%) | Morbidity (length of stay at ICU) | Technical Difficulty |
|---|---|---|---|
| 1 | <1 | 0-24 hours | Elementary |
| 2 | 1-5 | 1-3 days | Simple |
| 3 | 5-10 | 4-7 days | Average |
| 4 | 10-20 | 1-2 weeks | Important |
| 5 | >20 | >2 weeks | Major |

ICU: Intensive care unit

When evaluating these systems how accurate to evaluate patients time relatedly; ROC curves regarding the three scores for 120 days and 70 days are given (Fig. 1 and Fig. 2). As it is seen in these figures, ACS system is the most successful in determining death in the first ten days. ABS system comes second and RACHS system comes third. ABS system is the most successful in determining deaths between 10-20 days. ACS system comes second and RACHS system comes third. After 20th day, not being too apparent, RACHS system determines the deaths in long-term most successfully. ABS system determined the long-term mortality the worst.

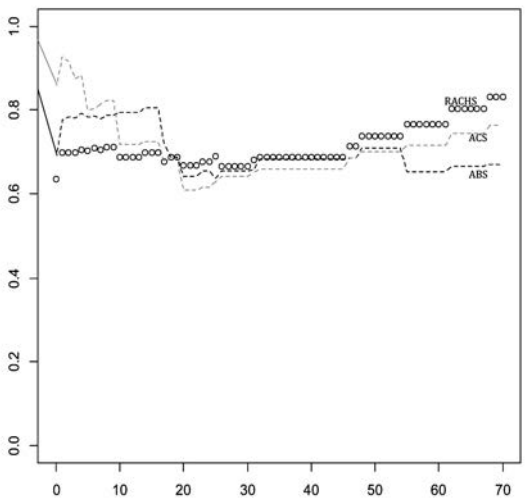


**Fig. 1.** Time related ROC curves for determining death in 120 days.

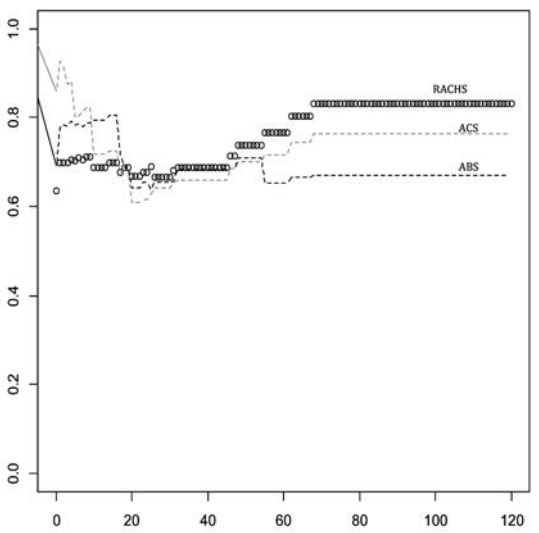


**Fig. 2.** Time related ROC curves for determining death in 70 days.

*Morbidity*

When the data obtained were evaluated, it was seen that 241 of 413 patients included in the study developed morbidity. While all patients included in the study were evaluated by ABS and ACS systems, there were 32 patients to whom procedures not included in the RACHS system were implemented.

151 of the 381 patients evaluated by RACHS system were seen not to develop morbidity. Average score of these patients were 1.8940. RACHS score of the 230 patient developing morbidity was 2.4087.

When patients were evaluated by ABS system, average score of the patients who did not develop morbidity (N=172) was 5.6302, and number of the patients developing morbidity was 241, average score was 6.7228.

In evaluation by ACS system, number of patients who did not develop morbidity was 172, average score was 6.9890, morbidity developing patients was 241 it was seen that the average scores of these patients were 9.5589.

When it was evaluated by the Mann-Whitney U test whether there were any statistically meaningful differences among these scores, it was found that all three scores are higher among the patients developing morbidity ($p<0,001$). It was seen that ACS system was the most accurate system in determining morbidity, in a similar way to the results in determining mortality, RACHS system followed this and the least accurate system was again the ABS system.

## Discussion

The results of the study were evaluated, it was seen that RACHS, ABS and ACS systems were successful in determining mortality in congenital heart diseases in a parallel way to the previous studies regarding these systems[4,5,10,11].

While the ABS system, which was the basis of ACS system was expected to foresee mortality more successfully than RACHS system, which was formerly developed and including less details, it was seen that RACHS system was more successful in foreseeing mortality than

ABS system surprisingly. In similar comparisons between ABS and RACHS, results were often controversial[10,12,13].

Although the purpose of the development of RACHS system was to determine the mortality only[3], it turned out to be effective in determining morbidity, too. Moreover, it was more successful than the ABS system, the development purpose of which was to determine both mortality and morbidity[5].

In many studies about these systems, while postoperative length of hospital stay was a parameter used in determining morbidity[5,10,11], in our study, postoperative length of intensive care stay was adopted as morbidity criterion. Although length of total stay in hospital includes intensive care duration, need of postoperative intensive care gives more apparent ideas regarding morbidity. Besides, even if it wasn't mentioned in many studies, length of stay in intensive care brought new morbidities itself, it was a factor increasing mortality as well as determining the morbidity. It must be determined more sharply and added to the scoring systems as an additional parameter in future studies that to what extent the postoperative length of stay and postoperative intensive care need, especially the postoperative intensive care need, are related to the morbidity and from which point they become the source of the morbidity.

In time related analyses regarding mortality, it was seen that ACS was the most successful system in foreseeing mortality in postoperative early term, ABS and RACHS systems followed this, yet this situation will prove to be right only after the morbidity concept is defined clearly. The fact that ACS system is successful in determining mortality in the first 10 days, ABS system is successful in determining mortality in 10-20 days and RACHS system is successful in determining mortalities after 20 days makes us think that ACS system determined the mortality developing patients more accurately considering the factors about the patient and for this reason the patients foreseen to develop mortality already die in the first 10 days.

As it can be seen in this study and former studies conducted in different centers[4,10,11], RACHS, ABS and ACS systems are successful systems in determining gain-loss ratio in congenital heart surgery candidate patients and in evaluating the performance of the centers where heart surgery is implemented.

When the results of this study are examined, notably ACS, RACHS and ABS systems will be effective in measuring and comparing the success and performance of the centers where congenital heart surgery is implemented and even of the individuals implementing congenital heart surgery and in evaluating in what ways the success of centers and individuals change and develop in time if used in general practice. They will be effective in correcting the deficiencies of the centers of individuals or constitution and standardization of more professional centers specialized in a certain subject or procedure.

## REFERENCES

1. Geissler HJ, Hölzl P, Marohl S, et al. Risk stratification in heart surgery: comparison of six score systems. Eur J Cardiothorac Surg 2000; 17: 400-406.
2. Lacour-Gayet F. Quality evaluation in congenital heart surgery. Eur J Cardiothorac Surg 2004; 26: 1-2.
3. Jenkins KJ, Gauvreau K, Newburger JW, et al. Consensus-based method for risk adjustment for surgery for congenital heart disease. J Thorac Cardiovasc Surg 2002; 123: 110-118.
4. Jenkins KJ. Risk adjustment for congenital heart surgery: the RACHS-1 method. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu 2004; 7: 180-184.
5. Lacour-Gayet F, Clarke D, Jacobs J, et al. The Aristotle score: a complexity-adjusted method to evaluate surgical results. Eur J Cardiothorac Surg 2004; 25: 911-924.
6. Lacour-Gayet F, Maruszewski B, Mavroudis C, et al. Presentation of the International Nomenclature for Congenital Heart Surgery. The long way from nomenclature to collection of validated data at th EACTS. Eur J Cardiothorac Surg 2000; 18: 128-135.
7. Mavroudis C, Jacobs JP. Congenital Heart Surgery Nomenclature and Database Project: overview and minimum dataset. Ann Thorac Surg 2000; 69: 2-17.
8. Jacobs JP, Jacobs ML, Maruszewski B, et al. Current status of the European Association for Cardio-Thoracic Surgery and the Society of Thoracic Surgeons Congenital Heart Surgery Database. Ann Thorac Surg 2005; 80: 2278-2283.
9. Heinrichs J, Sinzobahamvya N, Arenz C, et al. Surgical management of congenital heart disease: evaluation according to the Aristotle score. Eur J Cardiothorac Surg 2010; 37: 210-217.
10. Bojan M, Gerelli S, Gioanni S, et al. Comparative study of the Aristotle Comprehensive Complexity and the Risk Adjustment in Congenital Heart Surgery scores. Ann Thorac Surg 2011; 92: 949-956.

11. O'Brien SM, Jacobs JP, Clarke DR, et al. Accuracy of the aristotle basic complexity score for classifying the mortality and morbidity potential of congenital heart surgery operations. Ann Thorac Surg 2007; 84: 2027-2037.

12. Al-Radi OO, Harrell FE Jr, Caldarone CA, et al. Case complexity scores in congenital heart surgery: a comparative study of the Aristotle Basic Complexity score and the Risk Adjustment in Congenital Heart Surgery (RACHS-1) system. J Thorac Cardiovasc Surg 2007; 133: 865-875.

13. Kang N, Tsang VT, Elliott MJ, et al. Does the Aristotle Score predict outcome in congenital heart surgery? Eur J Cardiothorac Surg 2006; 29: 986-988.