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Congenital heart disease: interrelation between German diagnosis-related groups system and Aristotle complexity score

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Abstract

Objectives: The Disease-Related Groups (DRGs) system postulates that inpatient stays with similar levels of clinical complexity are expected to consume similar amounts of resources. This, applied to surgery of congenital heart disease, suggests that the higher the complexity of procedures as estimated by the Aristotle complexity score, the higher hospital reimbursement should be. This study analyses how much case-mix index (CMI) generated by German DRG 2009 version correlates with Aristotle score. **Methods:** A total of 456 DRG cases of year 2008 were regrouped according to German DRG 2009 and related cost-weight values and overall CMI evaluated. Corresponding Aristotle basic and comprehensive complexity scores (ABC and ACC) and levels were determined. Associated surgical performance (Aristotle score times hospital survival) was estimated. Spearman 'r' correlation coefficients were calculated between Aristotle scores and cost-weights. Goodness of fit 'r²' from derived regression was determined. Correlation was estimated to be optimal if Spearman 'r' and derived goodness of fit 'r²' approached 1 value. **Results:** CMI was 8.787 while mean ABC and ACC scores were 7.64 and 9.27, respectively. Hospital survival was 98.5%; therefore, surgical performance attained 7.53 (ABC score) and 9.13 (ACC score). ABC and ACC scores and levels positively correlated with cost-weights. With Spearman 'r' of 1 and goodness of fit 'r²' of 0.9790, scores of the six ACC levels correlated at best. The equation was $y = 0.5591 + 0.939x$, in which y stands for cost-weight (CMI) and x for score of ACC level. **Conclusions:** ACC score correlates almost perfectly with corresponding cost-weights (CMI) generated by the German DRG 2009. It could therefore be used as the basis for hospital reimbursement to compensate in conformity with procedures' complexity. Extrapolated CMI in this series would be 9.264. Modulation of reimbursement according to surgical performance could be established and thus 'reward' quality in congenital heart surgery.

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Keywords: Congenital heart disease; Cost analysis; Health economics; Health provider payments; Aristotle complexity score

1. Introduction

1.1. DRG system

The Disease-Related Group (DRG) system was initially developed, as of 1975, by Fetter [1] of Yale University. Germany adopted it in 2000, choosing and modifying the Australian DRG version. From 2004 on, the German Refined Disease-Related Groups has been implemented as the basis of hospital reimbursement and revised yearly. The 2009 version (the 6th one) (available at <http://www.g-drg.de>) comprises 1192 DRGs that are assigned by a classification algorithm depending essentially on principal diagnosis and various factors, in particular age, duration of mechanical ventila-

tion, surgical procedures and patient clinical complexity level (PCCL). PCCL is graded in German DRG, from 0 (no co-existing morbidity/complication) to 4 (concurrent very severe morbidity/complication), according mainly to (assumed) severity of diseases (clinical conditions) associated with the main diagnosis for which the patient is admitted and/or managed in the hospital (co-morbidity) and complications occurring during hospital stay (see <http://www.g-drg.de>). To each DRG corresponds one cost-weight value. Reimbursement is basically established for each case by multiplying the cost-weight by a base-rate lump sum. By adding all cost-weight values over a period (e.g., 1 year), one obtains a case-mix figure. This, divided by the total number of cases treated during the period, gives the case-mix index (CMI), which directly reflects mean reimbursement ratio for patients under care. Table 1 displays the 15 DRGs accounting for 98% of patients undergoing surgery for congenital heart disease, and their related cost-weight values for the year 2009.

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Table 1

Essential DRGs for paediatric cardiac surgery according to German DRG 2009.

DRG	Procedure and usual conditions	Cost-weight
I. Neonates: age under 28 days or infants with admission weight under 2.5 kg		
P02A	Most cardio-vascular operations, mechanical ventilation >480 h	35.132
P02B	Most cardio-vascular operations, mechanical ventilation: 144–480 h	16.651
P02C	Most cardio-vascular operations, mechanical ventilation <144 h	10.024
II. Other patients		
A09A	Cardio-vascular operations, mechanical ventilation: 500–999 h	25.377
A11A	Cardio-vascular operations, mechanical ventilation: 250–499 h	18.488
A13A	Cardio-vascular operations, mechanical ventilation: 96–249 h	12.374
F03B	Valve procedure in infancy, or deep hypothermia, or 3 valves repair	7.258
F03C	Some valve procedures, age ≥1 year, congenital or 2 valves repair	6.553
F03D	Valve procedure, age ≥1 year and <16 years, congenital or 2 valves repair	6.274
F03E	Valve procedure, age ≥16 years, congenital or 2 valves repair	5.692
F07Z	Other CPB procedures, infancy or complicating constellation ^a	5.774
F09A	Procedures without CPB, age <3 years	4.361
F30Z	Complex repairs ^b or hybrid surgery	7.930
F31Z	Other CPB procedures, age ≥1 year, and no complicating constellation ^a	4.870
F42Z	Heart surgery and heart catheterisation	9.658

CPB: cardio-pulmonary bypass.

^a Such as peritoneal drainage, dialysis/haemofiltration, resuscitation, massive transfusion of blood products, mechanical ventilation 48–95 h, etc.^b Such as main diagnosis of pulmonary atresia, truncus arteriosus, double outlet right ventricle, single ventricle, transposition of the great arteries, atresia of the aorta, atrial isomerism, and/or repair of tetralogy of Fallot, Norwood, Glenn and Fontan procedures, etc.

The DRG system is an effective tool to modulate expenditures in medical care. It enables also to monitor disease management and to compare different health-care providers over time. This may control and consequently lead to quality improvement in medical care.

1.2. Aristotle complexity score

Quality assessment is particularly important for surgical disciplines, especially those prone to substantial operative morbidity and mortality, such as paediatric cardiac surgery. In this sub-speciality, the surgeon is confronted with a wide range of operations, with different complexity levels, many of them done in an infrequent number. DRG may therefore reveal itself inadequate to determine hospital costs according to case complexity.

This has been addressed by the introduction of the Aristotle complexity score [2]. This score was developed from 1999 through September 2003 by a panel of international expert paediatric cardiac surgeons representing 50 centres and 23 countries, as a tool to evaluate performance in surgical management of congenital heart disease. It comprises two scores:

1. The Aristotle basic complexity score (ABC score). ABC score is a procedure-adjusted complexity (1.5–15 points) score: the sum of potentials for early mortality, morbidity (intensive care unit length of stay) and anticipated surgical technique difficulty (each, 0.5–5 points).
2. The Aristotle comprehensive complexity score (ACC score). ACC score (1.5–25 points) is the sum of ABC score and patient-adjusted complexity score (0–10 points). This includes procedure-dependent factors (0–5 points) and procedure-independent factors (general, clinical, extracardiac and surgical: 0–5 points).

The Aristotle methodology contains four ABC levels and six ACC levels: from the less complex level 1 with 1.5–5.9 points,

to the most complex level 4 with 10–15 points (ABC levels) or level 6 with 20.1–25 points (ACC levels). Performance is defined as complexity score (constant) multiplied by outcome (variable). Surgical (operative) performance, therefore, can be calculated as 'complexity times hospital survival'. It may be estimated for each surgeon, surgical unit and institutions, thus allowing comparison. ABC score has been largely validated [3,4]. We recently showed that the actual ACC score accurately assesses outcome of paediatric cardiac surgery in terms of mortality, morbidity and surgical technique difficulty [5]. Based on objective data of postoperative morbidity and mortality from large databases, an Aristotle average complexity score is actually under development [6].

1.3. Objectives

Common sense would advise to compensate and remunerate according to performance. The DRG system postulates that inpatient stays with similar levels of clinical complexity are expected to consume similar amounts of resources. This, applied to the congenital heart disease, suggests that the higher the complexity of procedures as estimated by the Aristotle score and the higher survival after surgery (surgical performance), the higher hospital reimbursement should be. Practically, case-mix index should correlate with either mean ABC score and/or mean ACC score, or operative performance observed in a paediatric cardiac unit. This study analyses whether (and by how much) case-mix index generated by German DRG 2009 version actually matches procedure complexity estimated by the Aristotle score.

2. Methods

The 476 DRGs attributed to our Department in the year 2008 were reviewed. Thirteen cases that were not operated upon and seven who underwent other surgical procedures (e.g., lung resection) not recorded in the Aristotle score model were

Table 2

Aristotle basic complexity (ABC) score and corresponding case-mix index (CMI).

ABC score	Cases number	CMI: mean $\pm$ SD	CMI: median	CMI: range
3	51	5.325 $\pm$ 2.253	4.870	2.035–18.490
4	8	7.012 $\pm$ 1.633	6.274	4.870–9.656
5	25	5.625 $\pm$ 0.939	4.870	4.870–7.258
5.5	1	4.870	4.870	4.870–4.870
5.6	3	7.154 $\pm$ 0.833	7.258	6.274–7.930
6	40	6.944 $\pm$ 2.683	6.274	2.860–12.370
6.3	14	8.706 $\pm$ 2.879	8.457	6.274–16.650
6.5	5	7.478 $\pm$ 1.261	7.258	6.553–9.656
7	49	10.040 $\pm$ 6.522	7.930	4.870–45.370
7.5	25	7.718 $\pm$ 1.654	7.930	5.774–12.800
7.8	1	9.656	9.656	9.656–9.656
8	101	7.738 $\pm$ 2.546	7.258	4.361–22.220
8.8	3	6.919 $\pm$ 1.084	7.053	5.774–7.930
9	50	10.360 $\pm$ 6.433	7.930	4.794–35.130
9.3	1	9.656	9.656	9.656–9.656
9.5	1	19.325	19.325	19.325–19.325
10	15	11.290 $\pm$ 4.864	10.020	6.274–25.380
10.3	9	8.729 $\pm$ 2.263	7.930	6.553–12.370
11	18	14.590 $\pm$ 9.802	10.020	5.774–42.530
12	2	18.880 $\pm$ 9.195	18.880	12.370–25.380
12.5	6	14.000 $\pm$ 4.978	15.190	7.930–18.490
14.5	24	14.580 $\pm$ 6.753	10.570	10.020–35.130
15	4	12.270 $\pm$ 3.125	11.200	10.020–16.650
Mean ABC score	Cases number	Mean CMI	Median CMI	CMI range
7.64 $\pm$ 2.79	456	8.787 $\pm$ 5.179	7.930	2.035–45.370

discarded. The remaining 456 were the subject of this study. They were regrouped according to the German DRG 2009 version. The resulting DRGs with related cost-weight values and co-morbidity level (PCCL) were recorded. Corresponding ABC and ACC scores were extracted from a database supplied by the Aristotle Institute, Denver, CO, USA (<http://www.aristotleinstitute.org>) as part of validation project of the Aristotle score. Cases were regrouped in complexity levels according to Aristotle methodology [2] and related mean ABC and ACC scores for each level were calculated.

Spearman 'r' coefficients were determined to investigate correlation between case-mix indexes and Aristotle scores. Two-tailed *P* value was calculated to answer the null hypothesis that there was no correlation in the overall cohort. Corresponding linear regression line was computed, with estimation of goodness of fit coefficient '*r*²'. Calculation for ABC and ACC scores was limited to surgical procedures with a minimum of eight same scores. Medians and means are given with range and standard deviation. The software GraphPad Prism (San Diego, CA, USA) was used for statistical computation. The significance was placed at *P* $\leq$ 0.05. Correlation was estimated to be optimal (almost perfect) if Spearman 'r' and derived goodness of fit '*r*²' approach 1 value.

3. Results

3.1. Parameters of DRG and Aristotle score

The five most frequent DRGs were F30Z (*n* = 85): complex repairs in patients aged more than 28 days, F31Z (*n* = 61): mainly closure of atrial or ventricular septal defect in

Table 3

Aristotle comprehensive complexity (ACC) score and corresponding case-mix index (CMI).

ACC score	Cases number	CMI: mean $\pm$ SD	CMI: median	CMI: range
3	10	4.35 $\pm$ 1.003	4.870	2.035–4.870
3.5	27	4.992 $\pm$ 0.485	4.870	4.870–7.258
4	8	6.469 $\pm$ 1.514	6.274	4.870–9.656
4.5	2	5.322 $\pm$ 0.639	5.322	4.870–5.572
5	19	5.208 $\pm$ 0.599	4.870	4.361–6.274
5.5	3	9.711 $\pm$ 7.615	5.774	4.870–18.490
5.6	3	7.154 $\pm$ 0.833	7.258	6.274–7.930
6	33	6.530 $\pm$ 2.295	6.274	2.860–12.370
6.3	5	7.700 $\pm$ 1.958	6.274	6.274–10.020
6.5	9	6.601 $\pm$ 2.710	4.870	4.870–12.374
7	19	6.980 $\pm$ 1.337	6.881	4.870–9.656
7.3	1	7.258	7.258	7.258–7.258
7.5	5	7.464 $\pm$ 0.726	7.930	6.274–7.930
7.8	2	7.965 $\pm$ 2.391	7.965	6.274–9.656
8	54	7.668 $\pm$ 2.210	7.930	4.361–12.800
8.3	2	8.289 $\pm$ 2.454	8.289	6.553–10.020
8.5	6	10.040 $\pm$ 5.574	7.930	6.553–21.130
8.8	1	5.774	5.774	5.774–5.774
9	36	8.300 $\pm$ 2.397	7.930	4.835–18.490
9.3	4	10.720 $\pm$ 4.249	9.840	6.553–16.650
9.5	13	7.317 $\pm$ 1.566	6.553	5.774–10.020
10	46	9.221 $\pm$ 4.673	7.930	4.870–32.810
10.3	3	10.110 $\pm$ 2.223	10.020	7.930–12.370
10.5	10	8.197 $\pm$ 2.063	7.930	4.794–12.710
10.8	1	7.053	7.053	7.053–7.053
11	30	8.761 $\pm$ 2.534	7.930	4.870–16.650
11.3	1	10.024	10.024	10.024–10.024
11.5	6	9.488 $\pm$ 2.012	10.020	6.553–12.370
12	18	11.880 $\pm$ 9.776	8.052	5.113–45.370
12.3	2	6.553	6.553	6.553–6.553
12.5	4	15.750 $\pm$ 6.121	16.420	7.930–22.220
12.8	2	8.793 $\pm$ 1.220	8.793	7.930–9.656
13	7	8.222 $\pm$ 2.247	7.930	6.274–12.370
13.3	3	7.706 $\pm$ 0.388	7.930	7.258–7.930
13.5	5	7.858 $\pm$ 2.543	6.553	6.553–12.370
14	5	16.190 $\pm$ 5.578	18.490	6.553–20.750
14.5	14	11.920 $\pm$ 3.961	10.020	7.930–18.490
15	7	11.590 $\pm$ 3.545	10.024	9.323–19.330
15.5	3	17.130 $\pm$ 11.570	12.370	8.698–30.310
16	1	35.132	35.132	35.132–35.132
16.5	2	20.580 $\pm$ 11.610	20.580	12.370–20.580
17	2	23.120 $\pm$ 16.980	23.120	11.116–35.132
17.5	4	10.020	10.020	10.020
18	2	26.280 $\pm$ 22.980	26.280	10.020–42.530
18.5	4	11.680 $\pm$ 3.314	10.020	10.020–16.650
19	3	18.130 $\pm$ 6.627	16.650	12.370–25.380
19.5	3	17.930 $\pm$ 7.868	18.000	10.020–25.760
20	2	21.010 $\pm$ 6.170	21.010	16.650–25.380
20.5	1	16.551	16.551	16.551–16.551
21	1	14.836	14.836	14.836–14.836
21.5	2	25.890 $\pm$ 13.070	25.890	16.650–35.130
Mean ACC score	Cases number	Mean CMI	Median CMI	CMI range
9.27 $\pm$ 3.80	456	8.787 $\pm$ 5.179	7.930	2.035–45.370

patients aged at least 1 year, P02C (*n* = 50): heart surgery in neonates with associated mechanical ventilation lasting less than 6 days, F03B (*n* = 42): valve procedure in infancy, and F03D (*n* = 36): valve procedure at age 1–15 years (see Table 1 for further DRG explanation). Mean PCCL was 3.53. Cost-weight values ranged from 2.035 to 45.370. Case-mix index for the whole series was estimated at 8.787.

The corresponding Aristotle complexity scores are displayed in Table 2 (ABC score) and Table 3 (ACC score) with, for

Table 4
Aristotle basic complexity (ABC) levels and corresponding cost-weights (CMI).

ABC level	Points range	Cases number	ABC score: mean $\pm$ SD	CMI: mean $\pm$ SD
Level 1	1.5–5.9	88	3.78 $\pm$ 0.97	5.621 $\pm$ 1.926
Level 2	6–7.9	134	6.71 $\pm$ 0.57	8.447 $\pm$ 4.537
Level 3	8–9.9	156	8.35 $\pm$ 0.48	8.648 $\pm$ 4.423
Level 4	10–15	78	12.15 $\pm$ 1.94	13.220 $\pm$ 6.912
Total	3–15	456	7.64 $\pm$ 2.79	8.787 $\pm$ 5.179

ABC: Aristotle basic complexity.

Table 5
Aristotle comprehensive complexity (ACC) levels and corresponding cost-weights (CMI).

ACC level	Points range	Cases number	ACC score: mean $\pm$ SD	CMI: mean $\pm$ SD
Level 1	1.5–5.9	72	4.08 $\pm$ 0.84	5.420 $\pm$ 1.860
Level 2	6–7.9	74	6.51 $\pm$ 0.52	6.845 $\pm$ 2.010
Level 3	8–9.9	116	8.56 $\pm$ 0.57	8.047 $\pm$ 2.604
Level 4	10–15	164	11.64 $\pm$ 1.61	9.938 $\pm$ 5.013
Level 5	15.1–20	26	17.88 $\pm$ 1.40	17.83 $\pm$ 9.863
Level 6	20.1–25	4	21.13 $\pm$ 0.48	20.820 $\pm$ 9.581
Total	3–21.5	456	9.27 $\pm$ 3.80	8.787 $\pm$ 5.179

ACC: Aristotle comprehensive complexity.

each score, the number of cases and related CMI indices. The five most frequent primary procedures were aortic valvuloplasty ($n = 37$, ABC score = 8), bidirectional cavo-pulmonary anastomosis ($n = 34$, ABC score = 7), primary closure of atrial septal defect ($n = 25$, ABC score = 3), patch repair of ventricle septal defect ($n = 24$, ABC score = 6) and Norwood procedure ($n = 24$, ABC score = 14.5). In general, mean ABC and ACC scores were 7.64 and 9.27, respectively. There were 13 sets of procedures with a minimum of eight same ABC scores and 15 sets for ACC scores. Scores for the four ABC levels and the six ACC levels with corresponding cost-weights (CMIs) are displayed in Tables 4 and 5, respectively.

There were seven deaths prior to hospital discharge, resulting in a hospital survival of 98.5% (449/456). Therefore, surgical performance attained 7.53 (ABC score) and 9.13 (ACC score) for this cohort of procedures.

3.2. Correlation between cost-weights (case-mix indexes) and Aristotle scores

Spearman's correlation coefficients r between Aristotle scores and cost-weights (CMIs) were 0.8901 for ABC scores and

0.9643 for ACC scores (Table 6). Corresponding best-fit linear regression line, including 95% CI bands, is depicted in Fig. 1(A) and Fig. 1(B), respectively. Related r^2 are 0.7746 and 0.8763.

Spearman r reached 1 value for scores of ABC and ACC levels. However, with a P of 0.0833, statistical significance was not achieved for ABC levels (see Table 6). Results of corresponding linear regression are shown in Fig. 2(A) for ABC levels ($r^2 = 0.9650$) and in Fig. 2(B) for ACC levels ($r^2 = 0.9790$).

Consequently the best correlation in this study was found between scores of the six ACC levels and cost-weights. The mathematic equation for the resulting regression is the following: $y = 0.5591 + 0.939x$, in which y stands for cost-weights (case-mix indexes) and x for scores of ACC levels.

4. Discussion

Yearly changes in the German DRG system brought significant improvement to hospital reimbursement after paediatric heart surgery in Germany. However, it is still a challenge to fairly match the complexity of this sub-speciality. For example, patient co-morbidity level (PCCL) does not play any role. Patients are essentially divided in two DRG groups (age under 28 days or infants under 2.5 kg, on the one hand, age at least 28 days or infants weighing at least 2.5 kg, on the other hand) that have poor clinical relevance for management of congenital heart disease. Moreover, the number of DRGs has steadily increased. The system becomes more and more complicated and the grouping software more expensive.

As shown in Table 1, the 2009 German DRG grouping for patients undergoing surgical repair of congenital heart disease essentially relies on procedure complexity. The Aristotle score is nowadays the only model that best evaluates procedure complexity and surgical performance. By coupling DRG grouping with Aristotle scoring, one would achieve the most correct compensation for medical care in this field and simplify DRG system at the same time.

In Table 6, Pearson's correlation coefficients (that assume data are sampled from Gaussian populations) are given for guidance only. We opine that only the non-parametric Spearman coefficients should be considered.

We found a good correlation and linear relationship between ABC and ACC scores with corresponding case-mix indexes, Spearman r correlation coefficients being around 0.9. Correlation was almost perfect (Spearman $r = 1$, and r^2 approaching 1: Fig. 2(B)) between scores of ACC levels and related CMIs. Therefore, the derived equation $y = 0.5591 +$

Table 6
Correlation coefficients ' r ' between Aristotle scores and cost-weights, corresponding P values, and ' r^2 ', goodness of fit coefficient for resulting linear regression.

Parameters	ABC scores	ACC scores	Scores of ABC levels	Scores of ACC levels
Spearman r	0.8901	0.9643	1	1
95% CI	0.6551–0.9681	0.8898–0.9887	—	—
P	<0.0001	<0.0001	0.0833	0.0028
Pearson r	0.8801	0.9361	0.9823	0.9894
95% CI	0.6389–0.9638	0.8143–0.9789	0.3798–0.9996	0.9027–0.9989
P	<0.0001	<0.0001	0.0177	0.0002
Goodness of fit r^2	0.7746	0.8763	0.9650	0.9790

ABC: Aristotle basic complexity, ACC: Aristotle comprehensive complexity, CI: confidence interval.

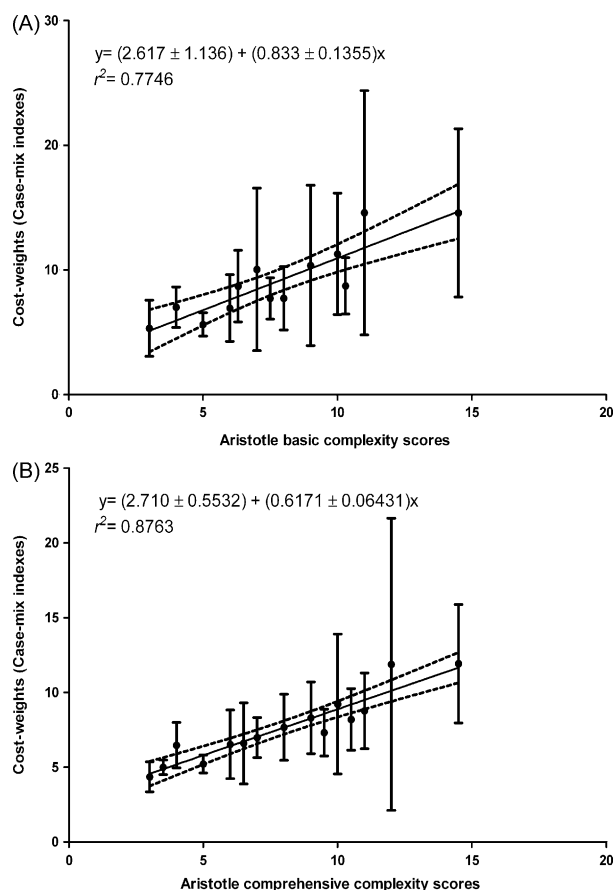


Fig. 1. (A) Linear regression line between Aristotle basic complexity scores (x) and cost-weights (case-mix indexes) (y). Vertical bars represent standard deviation. The band shows the 95% confidence interval. Corresponding equation and goodness of fit for linear regression ' r^2 ' are displayed. (B) Linear regression line between Aristotle comprehensive complexity scores (x) and cost-weights (case-mix indexes) (y). Vertical bars represent standard deviation. The band shows the 95% confidence interval. Corresponding equation and goodness of fit for linear regression ' r^2 ' are displayed.

0.939x constitutes the best formula to calculate the relationship between cost-weights (CMI) of German DRG and Aristotle score. The equation could be retained to determine case-mix index for hospital compensation. Knowing mean ACC score of procedures performed during a period of time (e.g., 1 year) in a unit, it would be possible to calculate the CMI to be used for this period for this institution. In this series, with a mean ACC score of 9.27, CMI to be applied would be 9.264. Modulation according to surgical performance could be easily established, to reward care quality. For example, mean ACC score could be replaced in the formula by corresponding comprehensive surgical performance. With an ACC surgical performance of 9.13 in this study, an 'effective' CMI of 9.132 could be contemplated. Reimbursement according to 'effective' CMI would not only mirror hospital costs, but also would have a strong impact in supporting units with high-quality care. Hospital reimbursement could also be modulated with regard to the level of postoperative morbidity encountered in a paediatric cardiac unit. However, a morbidity score in the Aristotle methodology is not expected before the year 2011 [6].

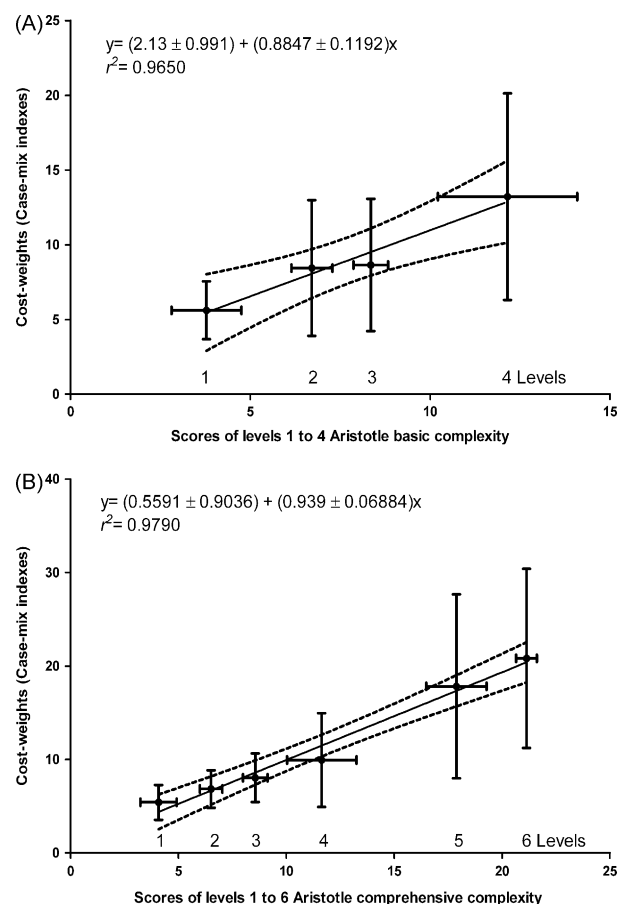


Fig. 2. (A) Linear regression line between scores of Aristotle basic complexity levels (x) and cost-weights (case-mix indexes) (y). Vertical and horizontal bars represent standard deviation. The band shows the 95% confidence interval. Corresponding equation and goodness of fit for linear regression ' r^2 ' are displayed. (B) Linear regression line between scores of Aristotle comprehensive complexity levels (x) and cost-weights (case-mix indexes) (y). Vertical and horizontal bars represent standard deviation. The band shows the 95% confidence interval. Corresponding equation and goodness of fit for linear regression ' r^2 ' are displayed.

The issue of 'rewarding' performance is highly sensitive. Nevertheless, it is likely that sooner or later, health-care payers will consider some sort of incentive to promote care quality. Paediatric cardiac surgeons will then need an accurate instrument to measure their performance to negotiate with health-care payers. Aristotle score is actually the sole risk stratification model that allows direct estimation of surgical performance. Kang et al. [7] have questioned accuracy of the performance equation promoted by Lacour-Gayet et al. [2]. This equation still seems to be valid and there is no other alternative formulation, which is accepted by the paediatric heart surgery community. It has to be remembered that the goal of the Aristotle score is performance evaluation and not outcome prediction [8].

5. Conclusion

In conclusion, the Aristotle complexity score, in particular, the comprehensive score, is emerging as a useful tool to measure surgical performance, and as such can be applied

to quality improvement efforts in the surgical management of congenital heart disease. This study clearly demonstrates that Aristotle comprehensive score and the related surgical performance could be effectively used for determination and adaptation of hospital reimbursement according to the German DRG system.

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Editorial comment

Congenital heart disease: interrelation between German diagnoses-related groups system and Aristotle complexity score

Keywords: Congenital heart disease; Congenital heart surgery; Health care; Cost-effective care; Aristotle score

Modern medicine can provide more care than society can afford. The cost of medical care is of worldwide concern. There is increasing pressure on doctors and hospitals to be ever more cost-effective, although the term 'cost-effective' is ill defined and biased by one's perspective. Too often, cost-effectiveness is defined by the short-term goal of restricting the cost of in-hospital care. However, in-hospital care is only a means to an end; an end that is the long-term survival, health and well-being of our patients.

Nowhere is the concern for cost-effective care more evident than in paediatric heart surgery where acute in-hospital care is expensive. Nevertheless, the short-term cost of paediatric cardiac surgery can be amortized over a patient's lifetime now that 90% of infants with congenital heart defects survive into adulthood and with the added potential of these healthy adults being productive in society.

With the above caveat regarding a broader concept of cost, Sinzobahamvya et al. from Germany focus on the important and timely issue of in-hospital cost for children requiring congenital heart surgery [1]. Since 2003, the German health-care system (the world's oldest universal health-care system that began in 1883) has used a 'case mix index' (CMI) to adjust in-hospital costs to the level of care required. They made the reasonable assumption that similar

levels of a child's clinical complexity will consume similar levels of resources (cost). Without doubt, fewer in-hospital resources are consumed by a child with an atrial septal defect than a neonate with a hypoplastic left heart syndrome. Therefore, it is appropriate to designate greater resources for children with more complex heart disease such as a hypoplastic left heart.

The essence of the Sinzobahamvya et al. thesis is that

- (1) higher complexity justifies higher reimbursement;
- (2) CMI and Aristotle scores correlate with case complexity and with each other; and
- (3) Sinzobahamvya et al. also address the issue of further adjusting reimbursement to reward institutions with better 'surgical performance' for equal levels of complexity.

Comments regarding these three points are as follows:

- (1) Higher complexity justifies higher reimbursement. This is self-evident. The only issue is how to establish a fair and appropriate adjustment, not only for levels of complexity within the wide spectrum of congenital heart disease but also in relation to all children with other non-cardiac diseases. That the German CMI has changed annually for the past 6 years is both an indication of how difficult cost adjustment may be and evidence of a commendable