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Retrospective evaluation of the simplified Therapeutic Intervention Scoring System (TISS-28) in a surgical intensive care unit

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Abstract *Objective*: To compare the simplified Therapeutic Intervention Scoring System (TISS-28) with its original version, to provide reference values of daily TISS-28 assessment and to describe its association with severity of illness in surgical patients.
Design: Retrospective evaluation of prospectively collected audit data; four documentation periods.
Setting: Ten-bed intensive care unit (ICU) in a surgical university hospital.
Patients: One thousand nine hundred eighty-six consecutive admissions (1,808 patients; 10,448 observation days) who stayed on ICU for at least 6 h. Patients were in hospital for abdominal, vascular or trauma surgery. The average age was 61.5 years, the mean APACHE II score on admission 10.3 points.
Interventions: None.
Measurements: Raw data for APACHE II score and TISS were recorded daily. TISS-28 was calculated retrospectively from the original TISS data.
Results: Average TISS-28 values (28.7 points; SD = 9.7) do not differ substantially from the original TISS values (28.2 points, SD = 10.9) and overall correlation is high ($r = 0.935$). Of the patients, 57.3 % left the ICU after 1–2 days as survivors with a mean daily TISS-28 of 20.0 points. Variability between documentation periods was higher with the original TISS. On average, patients with increasing severity of disease require an increasing amount of care. Survivors have lower TISS-28 values than non-survivors (27.6 vs 34.9).
Conclusions: In a surgical ICU the simplified version of TISS with 28 items (TISS-28) sufficiently reflects the amount of intensive care provided and may provide useful additional information on severity of disease and prognosis. It should replace the original index, at least in these cases.

Key words Intensive care unit · Score systems · Therapeutic Intervention Scoring System · Severity of illness index

Introduction

Since its introduction in 1974 the Therapeutic Intervention Scoring System (TISS) [1, 2] has been widely used and accepted as an instrument to measure therapeutic, diagnostic and nursing activities in intensive care. Although initially designed to measure severity of illness as well, it has been used almost exclusively for quantification of resource utilization and nursing workload. But the TISS was often criticized for being time-consuming, poorly defined, incomplete and outdated by medical technology. Many modifications of TISS are used to meet the local requirements of intensive care. This has led to a limited comparability between separate institutions.

In 1996, a simplified version of TISS with only 28 items (TISS-28) was published by Reis Miranda et al. [3] based on a detailed analysis of 10,000 records from

the database of the Federation for Research on Intensive Care in Europe. This new TISS-28 score is already widely used, although systematic evaluations in large groups of patients are still missing. Until now there have only been two multicenter studies, from Portugal [4] and Spain [5], but these investigations only consider data from the 1st day of ICU stay in mostly medical cases.

The present study evaluates both versions of TISS and gives detailed results from daily assessment based on a prospective database of adult surgical intensive care patients.

Materials and methods

Patients and setting

The surgical intensive care unit (ICU) at the 2nd Department of Surgery of the University of Cologne has ten beds and is directed in cooperation with the Department of Anesthesiology. Four out of five patients admitted to the ICU are postoperative cases. Patients treated in the ICU are admitted to the hospital for abdominal or vascular surgery, or after multiple injury. About half of the patients are admitted for postoperative surveillance and leave the ICU within 24 h after admission.

Data collection

In 1993 a quality control program was initiated with daily assessment of all patients who stayed on the ICU for at least 6 h. Documentation consisted of an initial assessment (age, sex, diagnostic category, chronic health, indication for admission) and subsequent daily assessment of the patients' physiology (e.g., temperature, blood pressure, heart rate) necessary for calculating the Acute Physiology and Chronic Health Evaluation (APACHE) II score [6]. The Glasgow Coma Scale was assessed only if the patient was not intubated or sedated, otherwise it was considered normal (15 points, i.e. no points in the APACHE II score). All interventions necessary for daily assessment of TISS were documented as well. The daily documentation period (usually 24 h) started at 6 a.m. with the morning shift. Periods of less than 6 h at the beginning or at the end of ICU stay were merged with the following or previous day, respectively. Raw data were collected from the patients' records and coded on a documentation sheet. On the same day, data were put into a computer database (RIYADH Intensive Care Programme, Medical Associated Software House, London, UK). Hospital outcome was retrospectively added to the database when the patient died or left the clinic. Data collection was carried out independently of the ICU staff by medical students (two per documentation period) who were initially trained and supplied with a manual for data management.

The quality control program was structured in four documentation periods each with a duration of 9–12 months. After each period an analysis was performed and the results were discussed internally. As soon as inconsistencies of documentation were observed, the existing manual for data collection was updated in order to clarify definitions and to improve the identification of the sources of data in the patients' records.

Scores

APACHE II and TISS score points were calculated by the documentation software. TISS-28 scores were composed retrospectively from the documented original TISS items according to the description given by Reis Miranda [3]. The number of therapeutic and nursing activities documented (n = 104) exceeded the number of the original TISS items (n = 76). Where applicable, non-TISS items were used to modify the calculated TISS-28 values (e.g. CT scan as a specific intervention outside the ICU, or renal dose of dopamine as medication). The Nine Equivalents of Nursing Manpower Use Score (NEMS) was calculated from a subset of TISS-28 items with appropriately modified weights [7].

Statistics

Data are presented as means and standard deviation (SD) where appropriate. Statistical tests were not applied in order to avoid arbitrary significant results based on the large number of cases rather than on clinically relevant differences. Association between TISS-76 and TISS-28 was assessed using Pearson's correlation coefficient, a linear regression analysis and a deviation plot according to Bland and Altman [8]. In this plot the difference between the two measurements (TISS-28 minus TISS-76) is plotted against its average magnitude [(TISS-28 + TISS-76)/2] for each patient. Stepwise logistic regression analysis was applied to evaluate APACHE II and TISS-28 on the day of admission for prediction of hospital mortality in primary admitted patients. Data analysis was performed with the statistical software package SPSS 9.0 (SPCC, Chicago Ill, 1997).

Results

During the total period of 40 months, 1,986 admissions were documented. Patients readmitted to the ICU during hospital stay (n = 178; 9.0%) were included in the analysis. One hundred fifty-eight patients died in the ICU (8.0% of all admissions). Total hospital mortality was 14.9% (based on 1,808 individual patients). The basic characteristics of the admitted patients are given in Table 1. Of the patients, 79% have had surgery prior to ICU admission (elective cases: 48%; emergencies: 31%). Most patients (58.9%; 1107 survivors; 30 non-survivors) left ICU within the first 2 days after admission. The mean ICU stay was 5.3 days (median: 1 day).

Among the 10,534 patient days documented, 10,448 days (99.2%; 1,953 admissions) had a valid TISS assessment. A total of 294,699 TISS-76 points were documented during the whole period. Mean daily TISS values were 28.2 (SD 10.9; range: 2–73) and 28.7 (SD 9.7; range: 4–61) for the versions with 76 and 28 items, respectively. Average daily TISS-28 values for diagnostic subgroups varied between 25.2 and 29.4. Highest values were observed in the group of trauma patients with the TISS-28 (1st day: 30.4; SD 10.6; n = 244 admissions/total: 29.4; SD 9.7; n = 3,111 days) as well as with the TISS-76 (31.2; SD 13.2 and 29.4; SD 11.2, respectively).

Table 1 Basic demographic data, severity of disease, ICU stay and hospital outcome for different diagnostic groups (*GI* gastrointestinal)

Diagnostic group	Patients No. (%)	Age Mean	Sex % Male	APACHE II Mean (SD)	Mortality %	ICU stay Mean/median
GI carcinoma	228 (11.5%)	66.4	60.5	9.5 (4.3)	10.1	3.2/1
Ileus; GI perforation	169 (8.5%)	65.6	46.7	12.0 (5.4)	21.9	5.8/2
Other GI disease	364 (18.3%)	59.8	56.0	10.5 (5.4)	19.8	5.3/2
Multiple trauma	246 (12.4%)	40.5	72.0	7.9 (4.9)	8.5	13.2/4
Fracture of the femoral neck	160 (8.1%)	76.2	20.0	11.0 (4.2)	19.4	2.3/1
Peripheral vascular disease	398 (20.0%)	64.4	66.1	9.3 (4.5)	10.8	1.9/1
Other vascular disease	185 (9.3%)	67.7	61.1	11.9 (5.3)	21.1	4.8/1
Respiratory problem	114 (5.7%)	58.2	63.2	11.8 (6.6)	22.8	8.0/2
Other	122 (6.1%)	59.8	53.3	11.2 (5.8)	23.0	6.2/2
Total	1986 (100%)	61.2	57.6	10.3 (5.2)	16.1	5.3/1

A histogram of TISS-28 values of all days is given in Fig. 1. The TISS-28 items most frequently observed were standard monitoring (99.7%), laboratory (96.4%), central venous line (92.8%), and quantitative urine output measurement (90.2%) (Table 2). Mean TISS values per day differed between the documentation periods (Table 3). A maximum difference of 6.7 points was observed for the TISS-76. Mean TISS-28 values showed minor variations (maximum difference 4.5 points).

TISS-28 correlates well with the original TISS-76 ($r = 0.935$, $r^2 = 0.87$; Fig. 2). The regression equation is TISS-28 = 5.3+0.83 * TISS-76. Correlation is also simultaneously high in the nine diagnostic subgroups (range: 0.911–0.949). The Bland and Altman plot (Fig. 3) shows the individual score differences. High values of TISS-76 tended to be decreased while low values were slightly increased on average. The mean NEMS was 27.6 points, the correlations with TISS-28 and TISS-76 were 0.83 ($r^2 = 0.69$) and 0.79 ($r^2 = 0.62$), respectively.

Patients who survived had a lower mean daily TISS-28 (27.6; 1,798 admissions; 8,846 days) than patients who died on ICU (34.9; 155 admissions; 1,602 days). Figure 4 gives a detailed distribution of average TISS-28 values according to the length of ICU stay for survivors and non-survivors. On the day of admission, mean TISS-28 was 25.0 (SD 9.5). Patients with 40 or more TISS-28 points on admission had an ICU mortality of 32.6% while patients with less than 20 points had a mortality of 2.7%. Stepwise logistic regression analysis in

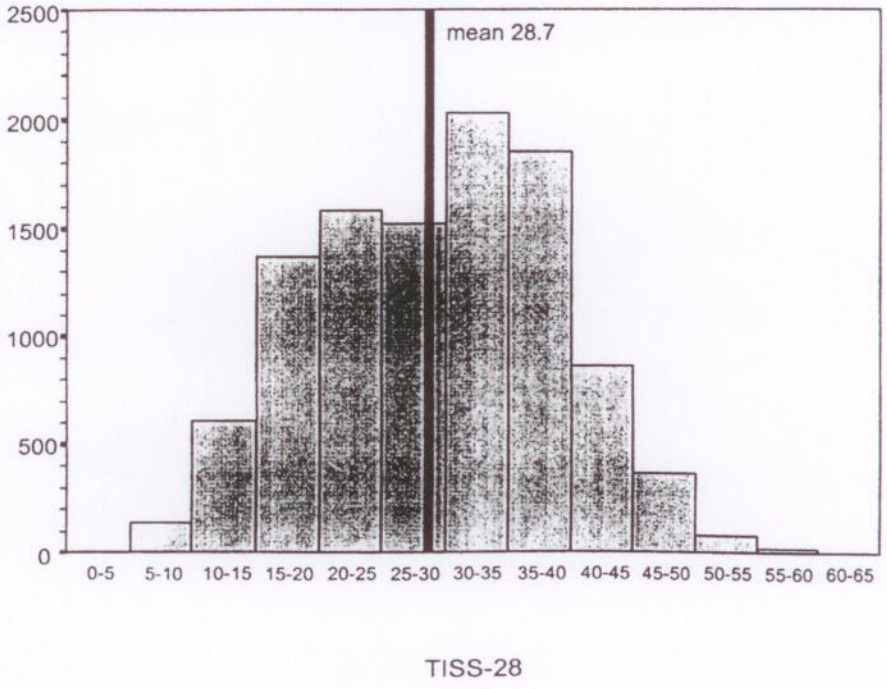

Fig. 1 Frequency distribution of 10,448 daily TISS-28 values from 1,953 ICU admissions

Table 2 TISS-28 items and prevalence among the 10,448 days with valid assessment of 1986 ICU admissions. For a detailed description of the items see Miranda et al. [3]

TISS-28 item	Points	Prevalence
Basic activities		
Standard monitoring	5	99.7%
Laboratory	1	96.4%
Single medication	2	31.3%
Multiple medication	3	66.6%
Routine dressing changes	1	55.7%
Frequent dressing changes	1	7.4%
Care of drains	3	38.5%
Ventilatory support		
Mechanical ventilation	5	54.9%
Supplemantary ventilatory support	2	25.5%
Care of artificial airways	1	57.4%
Treatment for improving lung function	1	69.1%
Cardiovascular support		
Single vasoactive medication	3	22.3%
Multiple vasoactive medication	4	14.1%
Intravenous replacement of large fluid loss	4	5.1%
Peripheral arterial catheter	5	59.7%
Left atrium monitoring	8	7.2%
Central venous line	2	92.8%
Cardiopulmonary resuscitation	3	0.3%
Renal support		
Hemofiltration techniques	3	6.1%
Quantitative urine output measurement	2	90.2%
Active diuresis	3	29.9%
Neurologic support		
Measurement of intracranial pressure	4	0.9%
Metabolic support		
Treatment of complicated metabolic acidosis/alkalosis	4	4.7%
Intravenous hyperalimentation	3	65.1%
Enteral feeding	2	31.9%
Specific interventions		
Single intervention in the ICU	3	16.6%
Multiple interventions in the ICU	5	0.8%
Specific interventions outside the ICU	5	14.4%

1,779 primary admitted patients revealed that the TISS-28 was included in the prediction model for hospital mortality in addition to the APACHE II score. The odds ratio of a 10 point increase in TISS-28 was 1.25 (logistic regression equation: 0.209*APACHE II +0.021*TISS-28 –4.798). The correlation with the APACHE II score based on the daily assessment of both scores was 0.45 ($r^2 = 0.20$). Mean TISS-28 values consistently increased with a higher degree of severity of illness as expressed by the APACHE II score (Fig. 5).

Thirty-three percent of patients were ventilated for at least 1 day. This rate increased to 70.5% for patients with an ICU stay of more than 2 days. Average TISS-28 for those days when a patient was ventilated was 34.7 (SD = 6.8; $n = 6042$ days) while days without artificial ventilation received only 20.4 points (SD = 6.3; $n = 4406$ days).

Daily TISS-28 scores demonstrate the improvement of health prior to discharge from ICU in survivors as well as severity of disease before death in non-survivors (Fig. 6). The median level of TISS-28 at discharge was 20 points in 1784 survivors. If patients left the ICU with 20 points or more, hospital mortality was 11.3%, while only 6.3% of patients with less than 20 points died later during their hospital stay. Cumulative TISS-28 (sum of all daily TISS-28 values during ICU stay) highly correlated with the number of days on ICU ($r = 0.984$; $r^2 = 0.97$) due to the stabilizing effect of patients with a long ICU stay. If only patients with an ICU stay of less than 6 days were considered, the correlation decreased to $r = 0.864$ ($r^2 = 0.75$).

Discussion

The Therapeutic Intervention Scoring System (TISS) is the only widely accepted and applied scoring system which exclusively relies on therapeutic, diagnostic and nursing activities. The first version of TISS, published in 1974 [1], consisted of 56 items, each with a point value

Table 3 Patients, outcome, days with valid TISS assessment and mean TISS values in the four documentation periods

	Phase I 7/93–4/94 9 months	Phase II 9/94–5/95 9 months	Phase III 6/95–5/96 12 months	Phase IV 9/96–6/97 10 months	Total 40 months
Admissions (*n*)	484	453	629	420	1986
Readmissions (*n*, %)	47 (9.7%)	28 (6.2%)	68 (10.8%)	35 (8.3%)	178 (9.0%)
Sex (% male)	55.2%	58.3%	59.5%	56.4%	57.5%
Age (mean, years)	63.0	61.3	60.4	61.8	61.5
APACHE II (mean, SD)	11.2 (5.3)	9.6 (5.1)	10.0 (5.3)	10.4 (5.0)	10.3 (5.2)
ICU mortality (%)	9.3%	11.0%	5.2%	7.1%	8.0%
Hospital mortality[a] %)	16.5%	17.2%	13.0%	13.3%	14.9%
ICU stay (mean, days)	5.2	5.1	5.8	6.8	5.7
Days documented (total)	2.252	2.500	3.285	2.497	10.534
Days with valid TISS assessment	2.181 (96.8%)	2.491 (99.6%)	3.283 (99.9%)	2.493 (99.9%)	10.448 (99.2%)
TISS-76 (mean, SD)	30.3 (10.6)	23.9 (10.7)	28.2 (10.9)	30.6 (10.0)	28.2 (10.9)
TISS-28 (mean, SD)	29.2 (9.3)	26.2 (9.9)	28.7 (9.6)	30.7 (9.3)	28.7 (9.7)

[a] based on primary admitted patients

between 1 (e.g., ECG monitoring) and 4 (e.g., mechanical ventilation) according to the time and effort required. In the 1983 revision [2], the number of items was increased to a total of 76 but still many users felt the need to modify and extend the TISS. Mälstam and Lind [9], for example, skipped seven items and introduced three new ones, which resulted in a 7% increase in average TISS values. Oye used a total of 90 items [10]. Dickie [11] mentioned a remark from P. Nightingale (ICNARC, London, UK) that a total of 471 different formulations of TISS items were currently used in the UK. He himself applied two local versions of TISS with 13 and 27 additional items, respectively [11]. Our own software program for data collection also offered 28 additional interventions. This inflation of items obviously decreases the comparability of reported TISS values.

The recent attempt of Reis Miranda and coworkers to simplify the TISS is, therefore, valuable [3]. They applied sophisticated statistical methods including factor analysis to reduce the number of items. Ten items with low influence on the total TISS were eliminated, the re-

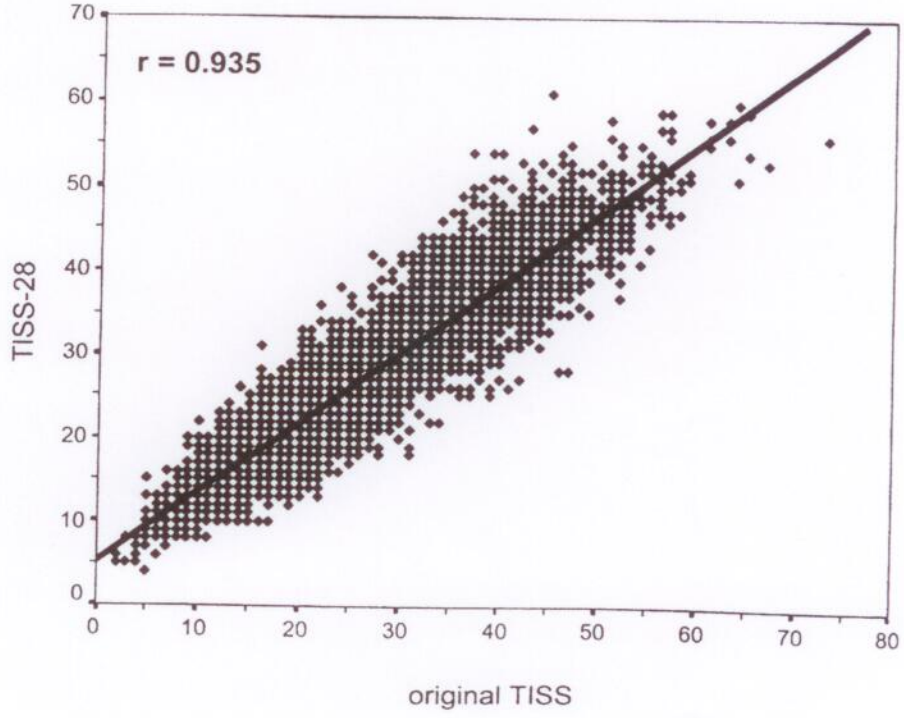

Fig. 2 Correlation of TISS-76 and TISS-28 values based on 10.448 patient days

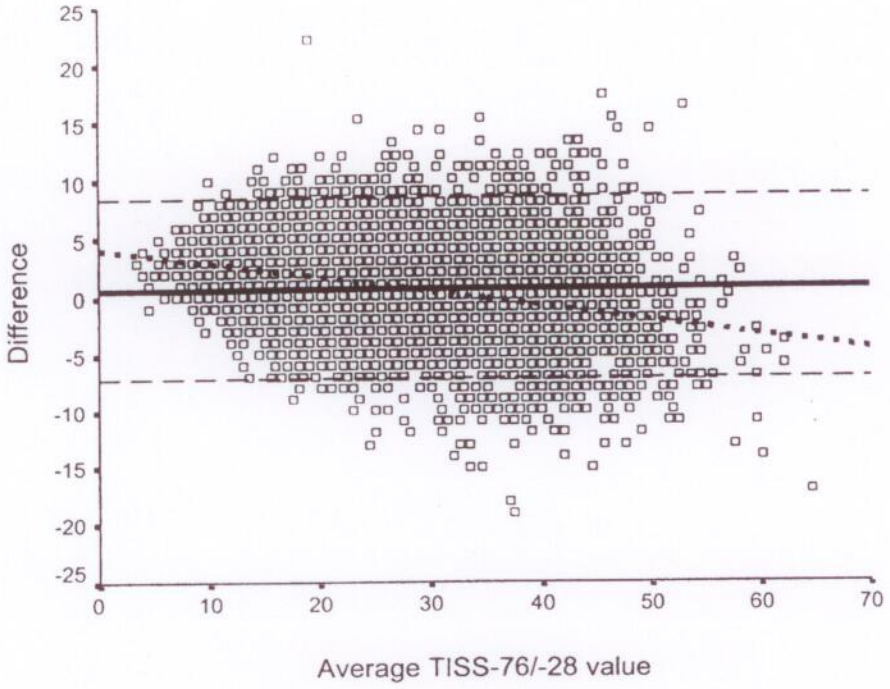

Fig. 3 Graphical presentation of agreement between TISS-76 and TISS-28 according to Bland and Altman [8]. For each patient, the average of both TISS values is plotted on the horizontal axis while the difference (TISS-28 minus TISS-76) is plotted on the vertical axis. The mean difference between the two scores is 0.6 *(solid line)*. The result of linear regression is given as a *dotted line*. The *dashed lines* represent the area of 2 SD around the mean difference

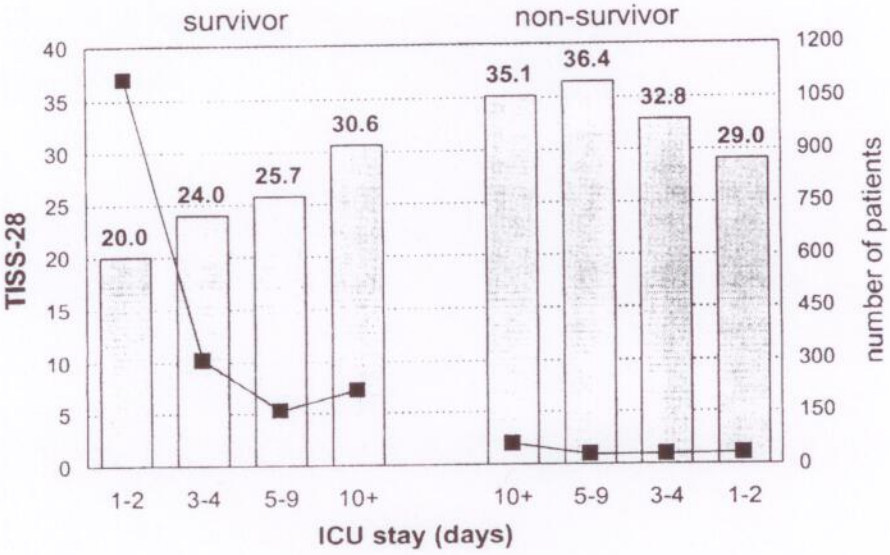

Fig. 4 Mean daily TISS-28 values *(bars)* and number of patients *(line)* according to ICU outcome and ICU stay

maining items were either kept ($n = 5$) or grouped together under new labels. The result was a list of 28 items (called TISS-28) grouped into basic activities and organ-specific interventions. New point values were calculated to imitate the original TISS score as closely as possible, at least on average.

But was this excellent effort to increase reliability and facilitate assessment of TISS really effective? Of course, the amount of time needed to document 28 instead of 76 items is obviously reduced. Furthermore, the chance of incidentally overlooking an intervention performed is higher with 76 items. But what is the price to pay for this simplification? Is one-third of the items still enough to give a meaningful description of a patient's care? Since the new score is based on the original TISS-76 items, it is possible to calculate TISS-28 retrospectively from these data. The inclusion of additional information from non-TISS items helps to imitate an in-

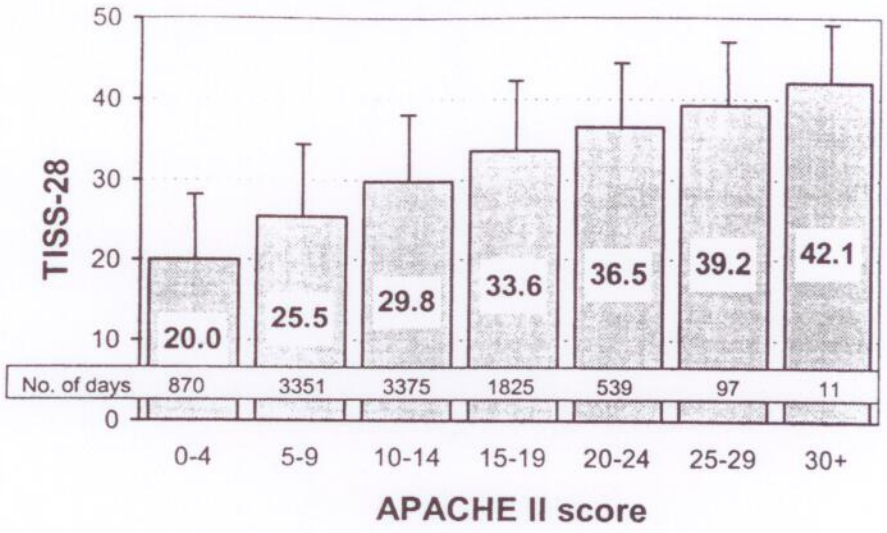

Fig. 5 Mean TISS-28 values according to levels of APACHE II score based on daily assessment of both scores. The *error bars* represent the standard deviation

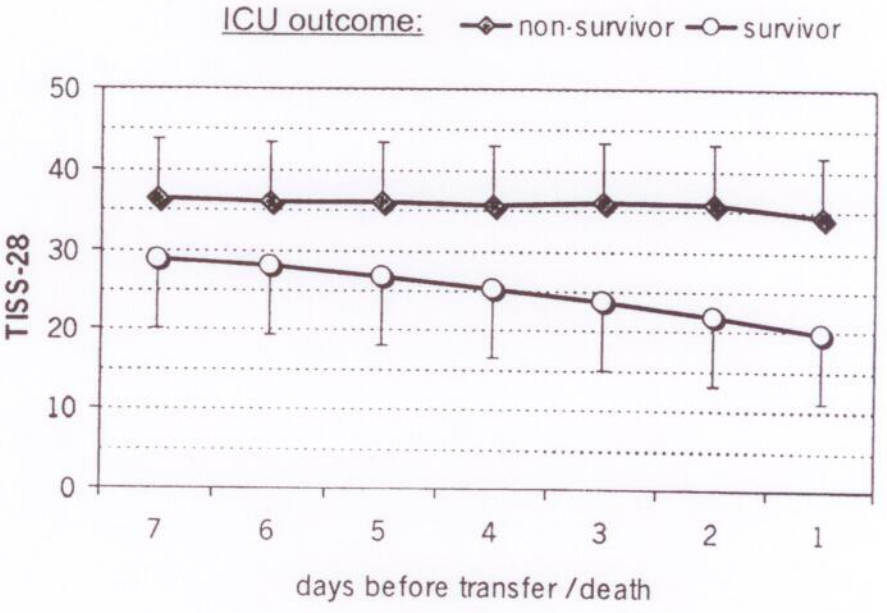

Fig. 6 TISS-28 for survivors (n = 288) and non-survivors (n = 68) at the end of ICU stay. Analysis was restricted to patients who stayed on ICU for at least 7 days. Mean values and standard deviations are plotted against the number of days prior to transfer or death, respectively

dependent TISS-28 assessment because the data collectors were aware of these interventions. But of course, our results were derived from an extended documentation of therapeutic interventions including the original TISS-76 items, and we did not score the TISS-28 directly. It is, thus, not a classical validation study where both scores are obtained in parallel and independently.

First of all, both versions of TISS are highly correlated and the mean difference is small in our data, as expected. Reis Miranda found a high correlation in the developmental data set (n = 10,000; r = 0.96) as well as in 1,820 new cases from 22 Dutch ICUs (r = 0.93) [3]. Independently, Moreno et al. [4] and Castillo-Lorente et al. [5] re-calculated the TISS-28 from existing data, as we did, and they both found a lower correlation of r = 0.85. But both authors considered data from the 1st day of ICU stay only. The fact that our correlation is higher might also depend on the more homogenous set of patients from a single center.

But correlation does not necessarily mean a satisfactory agreement in the individuals. In our patients, the new score differed by up to 20 points. On average, higher values tended to be decreased and lower ones to be increased. As a sequence, the variability of TISS-28 values is slightly decreased (see SD). This is a characteristic effect of item reduction, and it is further highlighted by

the fact that the slope of the regression line is less than one. This reduction process could further be continued by using the Nine Equivalents of Nursing Manpower Use Score (NEMS) [7], a subset of TISS-28 with nine re-weighted items. But two of these nine items do not help to differentiate between patients since they are more or less routinely provided on all days (basic monitoring and i.v. medication; prevalence > 97%). Thus the NEMS is more a rough classification tool than a detailed desciptor of intensive care.

Interestingly, the four studies mentioned above independently observed that mean TISS-28 values in groups of patients closely lie together: 28.8 [3], 29.8 [4], 28.0 (for the surgical subgroup) [5] and 28.7 in the present study, while mean original TISS-76 values differ substantially: 24.2, 31.1, 24.8 and 28.2, respectively. This might be caused by observer variations of the TISS-76. Furthermore, we observed a similar effect between our four documentation periods. Although the mode of documentation did not change and the groups of patients seem to be fairly comparable according to age, sex and severity of disease (Table 1), we found remarkable differences in mean TISS-76 values. These differences were less extreme with the TISS-28. The new TISS-28, therefore, seems to be less susceptible to observer variation and more appropriate for inter-institutional comparisons.

In the past, TISS has almost exclusively been used for quantifying resource allocation and nursing workload, although this was only one of its primary intentions. The ability to measure nursing workload is currently being investigated by a multi-national group, and additional items for specific nursing activities are going to be added (www.frice.nl/tiss/new-tiss, accessed on April 20, 2000). But TISS is also an indirect measure of severity of disease if one accepts that "*physicians intervene similarly and appropriately at each level of critical illness, and also that institutions are equipped to support many levels of interventions*" [12]. Although this cannot be expected in all situations, differences should be observable at least for groups of patients with a distinct prognosis. In the literature, non-survivors consistently show higher TISS values than survivors [9, 12, 13, 14, 15, 16, 17], which also could be demonstrated for the TISS-28 (Fig. 4 and [4]). Ventilated patients have higher TISS values. Wagner [18] found 29 TISS points per day on average for patients who were ventilated for at least 1 day as compared to 19 points for non-ventilated patients. In our data, average TISS-28 was 14 points higher on days when patients were artificially ventilated compared to days without ventilation, and this value clearly exceeds the 5 points given for artificial ventilation.

Not individual, but mean, TISS-28 values consistently increase with mean APACHE II values, as has been confirmed by several investigations [13, 19, 20, 21, 22]. But correlation of individual patient data was only 0.45, which was also observed by Castillo-Lorente et al. ($r = 0.54$) [5]. This indicates a considerable divergence, i.e. a remarkable number of patients have high TISS-28 values but a low APACHE II score, and vice versa. This can be explained by the different concepts of the two scores. The TISS only relies on therapeutic activities, while the APACHE score considers physiological data exclusively. But, indeed, the two aspects overlap. The physiology of a patient might be in a normal range because of a less severe disease or because of an optimal and intensive therapeutic support. TISS describes the status of a patient from a different point of view. The two pieces of information, the amount of therapeutic support as well as the physiological response to these interventions, may thus give a more complete view of the patient's current status. This is illustrated by the fact that the prediction of ICU outcome with APACHE II could be improved by including TISS-28 into the model. Wahl et al. [23] made the same observation.

That TISS contains additional severity of disease information can also be seen from the study by Dragsted et al. [24]. In a comparison of two hospitals he found nearly identical severity scores on admission, but a clear difference in hospital outcome (mortality 28.7% vs 39.8%). He could show that not only had the second ICU a greater proportion of pre-treated and trauma patients but also that average TISS values were higher (28.3 vs 36.0 points), which reflects the more severe status of these patients.

TISS-28 values do not tend to zero in survivors at the end of ICU stay. A median level of 20 points based on activities like standard monitoring, laboratory, output measurement, medication and nutrition can be observed during the last 24 h in ICU. Consistently, an increased level of therapeutic activities at the end of ICU stay is associated with a worse hospital outcome. Smith and colleagues also found that 21.4% of patients with a TISS of 20 or greater on discharge died subsequently during their hospital stays, while only 3.7% of patients with TISS below 10 died [25].

Cumulative TISS-28 values can serve as a measure to quantify the disease process as a whole, at least for survivors. All sequelae of the initial disease, as well as of secondary events (e.g. complications), are integrated in one summary measure. The cumulative TISS-28 weighs each event according to its therapeutic consequences. Therefore, TISS-28 might be considered for outcome assessment in situations where incidence rates of mortality or multiple organ failure are low. A first trial with the cumulative TISS-28 as the main outcome parameter has just begun [21, 26].

In conclusion, the reduced version of TISS with 28 instead of 76 items (TISS-28) is obviously easier to assess but still can describe patient care in the ICU in sufficient detail. TISS-28 highly correlates with the original TISS. Furthermore, it consistently increases on average with increasing severity of illness as measured by APACHE

II. Mean daily TISS-28 values are higher for patients with a long ICU stay, for non-survivors and for ventilated patients. It may contain useful additional information about severity of illness and prognosis. At least for surgical patients, the TISS-28 should replace the original TISS for monitoring patient care in the ICU.

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