

Examination of computer assisted prescribing of an initial calculated antibiotic treatment

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Abstract: The objective of this prospective clinical usage study was to examine the value of the rule based 'Therapeutic Assistant' integrated into an existing Patient Data Management System (PDMS) in helping to prescribe a initial antibiotic regime in accordance with the requirements of accepted guidelines. A prospective study comparing data before and after the introduction of the 'Therapeutic Assistant' was carried out. An adequate therapy resulted significantly more often after the introduction of the 'Therapeutic Assistant' [p<0.05]; however no difference between the regimes with and without the 'Therapeutic Assistant' in the period after its introduction could be established. Whether the 'Therapeutic Assistant' influenced the prescriptions made without it will have to be established in a further study.

Keywords: Protocol Drug Therapy, Computer-Assisted, Empirical Antimicrobial Therapy, Patient Data Management System

1. Introduction

In intensive care patients the occurrence of infections and their prompt and adequate treatment is a major factor in determining the eventual outcome for the patient. Apart from the surgical elimination of the source of the infection, the initial calculated antibiotic regime decisively influences the further course of the infection (10-12).

There are various strategies available to improve the initial calculated antibiotic regime (9;16). The introduction of information technology directly at the patient's bedside provides a possible alternative in the form of systems which support in

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decision making. (2;8;12;18). In the development of these systems it was repeatedly shown that, under laboratory conditions, they achieved their required goals. However they often fail in their routine use (19;12).

The objective of this clinical usage study was to examine the value of the rule based 'Therapeutic Assistant' integrated into an existing Patient Data Management System (PDMS) in helping to prescribe a calculated antibiotic regime in accordance with the requirements of accepted guidelines. In particular, changes in the quality of the treatment should be critically considered.

2. Study Context

2.1. System description

Since 1999 the surgical Intensive Care Unit (SICU) of the University Hospital, Giessen uses a PDMS (ICUData, Imeso GmbH) to document all medical data, including physicians' orders (14). The PDMS includes a decision support system for therapeutic guideline assistance since version 3.0 to help maintain standards when writing orders. As they are only suggestions, they are initially recorded in the chart as "not cleared" and must then be manually ordered by the physician. At this point, the physician can make any changes to the suggested therapy as needed. As such, the responsibility for therapeutic decisions remains with the physician.

Further co-operation with our Centre for Medical Microbiology and Virology has allowed to integrate an 'Antibiotic Wizard' module within the electronic patient record. This contains a catalogue of rule-based therapy standards for empirical antimicrobial therapy and is representative of the therapy recommendations of the Paul Ehrlich Gesellschaft (PEG) (21), modified for ICU in the spectra of resistances and pathogens. The graphical user interface (GUI) leads the physician to create a treatment plan based on rules defined in the database and uses a question and answer format (17).

The "Antibiotic Wizard" is designed to assist the ward physician in empirical antimicrobial therapy. Based on the PEG guidelines, the physician is given the standard operating procedures (SOP) available for treatment. This is meant to improve the quality of orders written, in that the program helps standardise antibiotic doses, combinations and duration of treatment. There is also a reminder feature that is integrated in the patient's chart, which after two or three days, shows the physician the antibiotic therapy ordered. This is to ensure that the antibiotic therapy is reassessed for the continuing presence of pathogens and to make any adjustments necessary (17).

2.2. Organisational Setting

The survey was done in the SICU with 14 beds and a throughput of approximately 1500 patients annually. Twice weekly (Tuesday and Friday) there is a microbiological (ward) round with a microbiologist together with the SICU Registrar (senior resident) and the house officers (residents). The current microbiological findings are discussed in these rounds, together with the antibiotic treatment as well as the patients' infective problems. Further therapeutic ideas are considered and ordered.

3. Methods

3.1. Study design

The microbiological rounds were accompanied regularly for six months before the planned training and introduction of the 'Therapeutic Assistant' "antibiotic Wizard" and this was continued after the introduction as part of the clinical routine (pre- and post-periods.) The survey covered a time span of 14 months, of which the pre-period was 142 days and the post-period was 272 days.

The physicians were asked about the indications of the calculated antibiotic regimes. They had to judge whether this therapy was successful or if there were reasons for an alteration of therapy. The standardised information for the study was entered in the PDMS in the course of the rounds. Only patients who had had at least one standardised round visit documented were included in the pre- and post-periods comparison. Patients who were treated in ICU during the time between two microbiological rounds could not be taken into account.

All the data necessary for the study were extracted from the PDMS using SQL scripts. These included among others age, sex, length of stay in ICU, duration of ventilation and deaths in ICU. The SAPS II score (13), the daily SOFA score (20) and the delta SOFA (15) were collected automatically (3;7).

3.2. Measurement of Outcome

On foot of the documented microbiological rounds and considering the microbiological findings a blind judgement was made — the antibiotic therapy was "adequate" or "inadequate" for its main purpose. Further outcome parameters were ICU mortality, the length of stay in intensive care, the duration of ventilation and the delta-SOFA, which counts as a measure of the decline in organ function whilst in the ICU and is therefore potentially influenced by therapeutic measures.

3.3. Data analysis

Using the Mann-Whitney-U test or the Chi^2 test significant differences ($p < 0.05$) between the two observation periods were sought. On the one hand, the period before the introduction of the "Antibiotic Wizard" (pre-period) was compared with the period afterwards (post-period); on the other hand a sub-group analysis was performed on the patients who had had at least one antibiotic regime proposed by the "Antibiotic Wizard" and the whole patient group in both the pre- and post-periods with the exception of the "Antibiotic Wizard" sub group. Three comparative group analyses in total were carried out to verify any possible influence of the rule-based 'Therapeutic Assistant' on the "adequate calculated antibiotic regime" in the quality of patient treatment. A further multivariable analysis to examine possible degree of influence on the outcome parameters would have been meaningless due to the limited number of cases.

4. Results

There were 43 patients in the pre-period who had documented microbiological rounds; the "Antibiotic Wizard" was used in 35 out of the 113 post-period patients. Table 1 shows the whole patient group; table 2 shows the statistics for the comparative group analyses.

Table 1: All patients and Outcome parameters (bold)
MV = Mean Value, SD = Standard deviation, CI = Confidence interval, IQS = Interquartile range

	Pre-Period (43 Patients)				**Post-Period (113 Patients)**			
parameters	**MV ± SD**	**CI**	**Median**	**IQR**	**MV ± SD**	**CI**	**Median**	**IQR**
age [Years]	59.9 ± 20,1	[53,7 ; 66,1]	66,1	[45,1 ; 76,2]	56,9 ± 18,9	[53,4 ; 60,4]	61,3	[44,3 ; 71,0]
SAPS II	49 ± 15	[44,5 ; 53,8]	44	[40 ; 61]	48 ± 12	[45,4 ; 49,8]	48	[40 ; 54]
SOFA (Admission at ICU)	6.4 ± 2,6	[5,6 ; 7,2]	6	[5 ; 8]	6,1 ± 2,4	[5,7 ; 6,6]	6	[4 ; 8]
Delta-SOFA	1,9 ± 2,3	[1,2 ; 2,7]	1	[0 ; 3]	1,4 ± 1,9	[1,0 ; 1,8]	1	[0 ; 2]
length of stay (ICU) [h]	472 ± 538	[307 ; 638]	376	[209 ; 524]	337 ± 275	[286 ; 389]	270	[122 ; 479]
duration of ventilation [h]	254 ± 274	[169 ; 338]	197	[46 ; 365]	178 ± 207	[139 ; 217]	106	[14 ; 276]
adequate therapy	**47,8 ± 30,7**	**[38,3 ; 57,2]**	**50**	**[33,3 ; 68,2]**	**66,5 ± 30,5**	**[60,8 ; 72,2]**	**75**	**[50 ; 91,3]**
evaluation of therapy success	**34,3 ± 43,0**	**[21,0 ; 47,5]**	**0**	**[0 ; 100]**	**63,6 ± 44,2**	**[55,4 ; 71,9]**	**100**	**[0 ; 100]**
	yes no	**%**			**yes no**	**%**		
gender (male)	32 11	74,4			67 46	59,3		
mortality in ICU	**18 25**	**41,9**			**30 83**	**26,5**		

	Post-Period orderd by Wizard (35 Patients)				**Post-Period without Wizard (78 Patients)**			
parameters	**MV ± SD**	**CI**	**Median**	**IQR**	**MV ± SD**	**CI**	**Median**	**IQR**
age [Years]	57,2 ± 20,4	[50,2 ; 64,2]	66,7	[43,34 ; 72,93]	56,8 ± 18,3	[52,7 ; 60,9]	59,2	[45,6 ; 69,6]
SAPS II	45 ± 12	[40,8 ; 49,3]	43	[35 ; 53]	49 ± 11	[46,2 ; 51,3]	49	[42 ; 55]
SOFA (Admission at ICU)	6,2 ± 2,5	[5,3 ; 7,0]	5	[4 ; 8]	6,1 ± 2,4	[5,5 ; 6,6]	6	[4 ; 8]
Delta-SOFA	1,1 ± 1,4	[0,6 ; 1,6]	1	[0 ; 2]	1,6 ± 2,1	[1,1 ; 2,0]	1	[0 ; 3]
length of stay (ICU) [h]	388 ± 300	[285 ; 491]	296	[136 ; 645]	315 ± 262	[255 ; 374]	234	[120 ; 445]
duration of ventilation [h]	189 ± 249	[104 ; 275]	99	[10 ; 216]	173 ± 187	[130 ; 215]	108	[17 ; 284]
adequate therapy	**72,5 ± 26,3**	**[63,4 ; 81,5]**	**75**	**[53,1 ; 100]**	**63,8 ± 32,1**	**[56,5 ; 71,0]**	**74**	**[50 ; 87,9]**
evaluation of therapy success	**64,8 ± 41,4**	**[50,6 ; 79,0]**	**100**	**[33,3 ; 100]**	**63,1 ± 45,7**	**[52,8 ; 73,4]**	**100**	**[0 ; 100]**
	yes no	**%**			**yes no**	**%**		
gender (male)	22 13	62,9			45 33	57,7		
mortality in ICU	**6 29**	**17,1**			**24 54**	**30,8**		

Table 2: Statistics for the comparative group analyses

	Mann-Whitney-U-Test (p-Value)		
parameters	**pre-period vs. post-period**	**pre-period vs. Wizard-Pat.**	**Wizard-Pat. vs. Post (Ø Wizard)**
age [Years]	0,28	0,52	0,55
SAPS II	0,94	0,29	0,08
SOFA (Admission at ICU)	0,52	0,58	0,98
Delta-SOFA	0,23	0,18	0,63
length of stay (ICU) [h]	0,07	0,51	0,29
duration of ventilation [h]	0,07	0,13	0,71
adequate therapy	**< 0,01**	**< 0,01**	**0,24**
evaluation of therapy success	**< 0,01**	**< 0,01**	**0,97**
		X^2-Test (p-Value)	
gender (male)	0,10	0,33	0,68
mortality in ICU	**0,06**	**< 0,05**	**0,17**

5. Discussion

It was shown that, in the post-period in which the “Antibiotic Wizard” was available, the assessment of the antibiotic therapy as adequate was significantly more frequent and less frequently assessed as inadequate, and the treatment was more often evaluated as successful. In the patient group whose initial antibiotic regime was prescribed using the “Antibiotic Wizard” the relative frequency of adequate treatment from an average of 47.8% in the pre-period to 72.5% in the post-period. At the same time the rate of inadequate treatment decreased from 34.2% to 18.5% in average. In a large multicentre trial of 904 patients Harbarth et al. showed a similarly high incidence of inadequate initial antibiotic treatment in 23% of cases (5). The total mortality in this study was 24% (168/693) among the adequately treated cohort compared to 39% (82/211) in those with inadequate initial therapy (5). Ibrahim and Leibovici demonstrated that an initially inadequate antibiotic treatment clearly increased the mortality (61.9% vs. 28.4% or 34.3% vs. 20.2% (6)). In spite of a smaller case number in this study and the absence of proof of a correlation between adequate therapy and ICU mortality, a similar reduction in mortality from 40.9% in the pre-period to 26.5% in the post-period was observed. In those patients whose antibiotic regimes was prescribed using the ‘Therapeutic Assistant’ the mortality rate was 17.1%, which was significantly less than in the pre-period.

The treatment improved in the post-period both with and without the wizard. How far this is a advantage of the “Antibiotic Wizard” needs to be examined. Besides the use of the ‘Therapeutic Assistant’ as a reference work without using it to prescribe, the documentation of the microbiological rounds may have led to an increased level of care in the prescribing of antibiotic treatment by the physicians. It is therefore possible that another study might show that, in spite of computer assisted prescribing, the communication between ICU physicians and infection specialists is responsible for the correct antibiotic usage (1).

The reasons for the limited prescribing using the “Antibiotic Wizard” need to be ascertained. Other studies have shown that, through the use of a decision support system, the prescription of an empirical initially adequate antibiotic regime rose from an initial 77% to 94% (4). In our study this high improvement rate could not be achieved. However the conclusions, with an improvement of initial antibiotic treatment adjudged to be adequate from 47.8% to 72.5%, are very promising.

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7. References

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