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Medical invasive devices utilization and nosocomial infection incidence rates associated to these devices, estimated through standardized prospective surveillance in a pediatric intensive care unit from Bucharest municipality

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ABSTRACT

***Time and Setting**: study was conducted during 2005-2006 time period, in the pediatric intensive care unit of the "Grigore Alexandrescu" university clinic, Bucharest, Romania.*

***Objectives**: (a) estimate the medical invasive devices' utilizations rates and also the incidence rates of the nosocomial infection (NI) temporally associated with these devices, and (b) interpret the meaning of observed rates by comparing with the expected distributions provided by National Nosocomial Infection Surveillance System (NNISS), of the Center for Disease Control and Prevention (CDC), USA.*

***Methods**: descriptive prospective study of a cohort (n=2593) represented by patients consecutively admitted in the pediatric intensive care unit of an important pediatric university clinic from Bucharest municipality; the NNISS methodology has been used for data collecting, calculating rates and interpretation of the results.*

***Results**: standardized rates of utilization (exposure days by patient-days) of mechanical ventilator, central vascular catheter and urinary catheter were: 0.11, 0.17 and 0.33 respectively; the standardized incidence rates of NI temporally associated with urinary catheterization, mechanical ventilation and central vascular catheterization were: 0.0, 3.6 and 9.3 cases per 1000 days of exposure to correspondent device.*

Empirical comparison of the observed rates in our unit with expected distributions reported by NNISS suggested the following: (a) devices utilization*: mechanical ventilator and central vascular catheterization appear as underutilized (most probably by inappropriate (but unavoidable) including in the study cohort of those patients (usually after ordinary surgery) admitted in PICU only for a short time of enhanced surveillance, but not necessary for invasive support of failed biological functions/systems and (b)* device associated NI incidence*: on one hand, the urinary tract infection appears as underreported (detecting failure) and on the other hand, the incidence of bloodstream infection was positioned between the percentiles 75th and 90th of the expected distribution, being a matter of concern (although not true outlier).*

***Conclusions:** 1) Nosocomial infection rates observed in our study are reasonably fitted into the NNISS distributions. 2) Underutilization of some medical invasive devices found in our study is merely reflecting the local rules, then true deviations from medical practice standards. 3) By comparing with expected distributions, the standardized prospective NI surveillance in pediatric ICU allows comprehensive evaluation of the infection control program's quality, enables implementation of proper corrective measures and their effective evaluation.*

Key words: pediatric ICU, nosocomial infection, medical invasive devices utilization

INTRODUCTION

It was documented that the all sites nosocomial infection rate of calculated to 100 patients or 1.000 hospital-days, significantly correlates with both the length of stay in hospital and also with medical invasive devices (mechanical ventilator, central vascular catheter and urinary catheter) utilization rates; the meaning of this observation is that these rates are highly specific to each individual hospital and consequently it is not recommended to use these rate for national or international comparisons for external quality control. By contrast, the density incidence rates adjusted in function of the exposure to medical invasive devices (example: cases of urinary tract infection associated to urinary catheter/days of exposure to urinary catheter) do not correlates to the hospital indelible characteristics like as number of hospital beds or lengths of stay in hospital, giving to these type of rates the merit of being eligible for valid comparisons (1).

The pediatric intensive care unit in which we conducted the present study is part of an important teaching clinic for children, medicine owning 399 hospital beds and hosting medical, toxicology, surgery, trauma, plastic surgery and burns departments. The pediatric intensive care unit (PICU) is a 30 beds wide department, provided with specialized medical equipment and staffed by personnel highly competent and experienced for caring about pediatric medical emergencies (come, seizures, acute respiratory

failures), surgical and orthopedic (including politrauma) emergencies, extended skin burns accompanied by inhalatory injury necessiting ventilator support, and also for postoperatory care after big (kidney, tumors, internal organs trauma) or ordinary surgery, in patients coming from inner and equally outside territory of the Bucharest municipality.

Preoccupied by increasing of the quality of medical services provided to consumers, the hospital management decided implementation of the standardized prospective surveillance of nosocomial infections associated to the medical invasive devices utilization in PICU aiming to: (a) prove the feasibility of the NNISS methodology's integration in the own unit, (b) compare the own rates of MID(medical invasive device) utilization and also the NI rates associated to these devices with the reference represented by NNISS distributions and, (c) eventually revise the existing rules of medical and/or nursing practices according to the results collected. Description of the methods used, the results obtained after a two years time of surveillance (2005-2006), and the authors' comments regarding these results are presented in the present paper. ❑

METHODS

Medical conditions surveyed: for the aim of this study the following nosocomial infections were prospectively surveyed: (a) urinary tract infection temporally associated with indwelling urinary catheterization, (b) lower respiratory tract infection temporally associated with mechanical assisted ventilation, and (c) bloodstream infection temporally associated with central vascular lines.

Data collection and management:

a) Monitoring of exposure: daily, a member of the hospital infection control (IC) team visited the hospital PICU and wrote down the following four frequencies: number of patients existing in the unit in visit day, number of patients with central vascular lines, number of patients mechanically ventilated and number of patients with indwelling urinary catheter. At the end of the daily visit in PICU, the noted figures have been introduced align to the respective calendar day in an MS Excel© electronic format on the IC team's computer machine.

b) Detecting of cases: IN cases of lower respiratory tract, urinary tract or bloodstream, passively reported by patient's attending physician or actively found by the hospital epidemiologist during her biweekly clinical rounds were electronically registered in order to be later assessed for confirmation as nosocomial infection, eventually temporally association with the corresponding MID (2).

Definitions of NI associated with MID: NNISS algorithm was used, in a step-by-step approach, to classify each suspect medical condition as: (a) infection, (b) nosocomial and (c) temporally associated with MID, respectively (3,4).

CDC's case-definitions released in 1988 (4) have been used to confirm nosocomial pneumonia, bloodstream and urinary tract infections; (in 2005, when the present study was launched, operationally, it was too early to use the 2004 CDC criteria (3) for nosocomial pneumonia cases definitions).

Enrolled patients: enrolled subjects were patients consecutively admitted to PICU during 2005-2006 period time, only when the hospital admission and discharging dates were different (2).

Calculation of rates: the NNISS method has been used (Table no.1 and Table no.2) (5) for the calculation of standardized rates of NI incidence and MID utilization during 2005-2006 time period.

Interpretation the meaning of the observed rates: the values of the rates observed in PICU (utilization and incidence) have been empirically compared (i.e. by juxtaposing) with the standard represented by corresponding percentiles distributions, provided in the most recent electronically published report by NNIS system (5). Essentially this matching exercise is performed for finding the observed rates which significantly deviates (outliers) from the expected median values (or the 50th percentile), namely the values smaller then those iterated at 10th percentile position or higher then those iterated at 90th position of the expected distribution (Table 1).

RESULTS

During 2005-2006 time period, a number of 2593 were admitted for at least one day in the hospital PICU. The sum of each patient length of stay in hospital counted for 7700 patient-days.

Standardized rates of urinary catheter, mechanical ventilator and central vascular catheter utilizations were: 0.33, 0.11 and 0.17

Classes of expected rates (in percentiles)	Meaning of the own rate's position by juxtaposing to expected distribution	
	MID Utilization	MID associated incidence rates
< 10 % (outlier)	Underutilization	Underreporting
10% – 25%	*Warning (pre-alert)*	
25% – 75%	Expected utilization	Expected incidence
75% – 90%	*Warning (pre-alert)*	
> 90% (outlier)	Overutilization	Cases in excess

TABLE 1. Qualitative stratifying algorithm of the observed rates depending on their position into the ranking of expected distribution, provided by NNIS system (5).

Medical Invasive Device (MID)	Number of days of exposure to the MID indicated	Utilization Rates* of the MID Indicated
Urinary catheter	2556	0.33
Mechanical ventilator	839	0.11
Central vascular catheter	1297	0.17
**) Number of exposure days to the indicated MID / Sum of patient-days (n=7700)*		

TABLE 2. MID's utilization rates observed in "Grigore Alexandrescu" clinic's PICU, Bucharest municipality, 2005-2006.

Anatomic sites exposed to MID	Observed number of NI cases	Number of exposure days to MID[a,b,c]	NI Rate[d] by shown anatomic site
Urinary tract	0	2556[a]	0.0
Lower respiratory tract	3	839[b]	3.6
Bloodstream	12	1297[c]	9.3
[a)]Urinary catheter; [b)]Mechanical ventilator; [c)]Central vascular line			
[d)](Number of MID associated NI cases / Number of exposure days to MID) x 1000			

TABLE 3. MID associated NI rates, observed in the "Grigore Alexandrescu" clinic's PICU – Bucharest municipality, 2005-2006.

Medical Invasive Device (MID)	Expected distributions in percentile											
	/	10%	/	25%	/	50%	/	75%	/	90%	/	
Urinary catheter		0.11		0.20		0.30	▲	0.41		0.7		
Mechanical ventilator	▲	0.17		0.25		0.36		0.49		0.57		
Central vascular line	▲	0.20		0.31		0.46		0.57		0.64		
(▲): *here we are*												

TABLE 4. The results of empiric comparing of the own MID utilization rates (▲) with the expected correspondent NNISS distribution – "Grigore Alexandrescu" Clinic's PICU, Bucharest, 2005-2006.

Anatomic site affected with nosocomial infection	Expected distributions in percentile											
	/	10%	/	25%	/	50%	/	75%	/	90%	/	
Urinary tract		0.0	•	1.6		3.6		6.1		8.1		
Lower respiratory tract		0.0		0.9		2.3	•	4.8		8.1		
Bloodstream		0.9		3.0		5.2		8.1	•	11.2		
(•): *here we are*												

TABLE 5. The results of empiric comparing of the own NI incidence rates (●) with the expected correspondent NNISS distribution – "Grigore Alexandrescu" clinic's PICU, Bucharest, 2005-2006.

days of exposure per patient-days, respectively (Table no. 2).

Standardized incidence rates of MID associated nosocomial urinary tract, lower respiratory tract and bloodstream infections, respectively were: 0.0, 3.6 and 9.3 cases per 1,000 exposure days (Table 3).

Empiric comparing against the corresponding distributions reported by NNIS system enabled us to classify our rates as following:

- *MID utilizations*: urinary catheter utilization rate falls within the excepted limits; however, the mechanical ventilator and central vascular line utilization rates were smaller than the value expected at 10th percentile of reference distribution (outliers), suggesting a level of underutilization of these two devices (Table 4);
- *MID associated NI incidences*: the NI incidence of lower respiratory tract did falls within the expected limits, the incidence of urinary tract NI was smaller than the 25th percentile of the expected distribution, suggesting underreporting (perhaps detecting failure) and the observed incidence of bloodstream NI was positioned between the 75th and 90th percentiles of the expected distribution, indicating relatively excess of cases; (exactly this value is not a true outlier, but a matter of concern anyway) (Table 5).

DISCUSIONS

Data collected during 1992-1997 from 61 US pediatric intensive care units (110,709 patients with 6,290 nosocomial infection episodes) documented that 64% of cases were represented by infections of three major anatomic sites, ranked as follows: bloodstream, lower respiratory tract and urinary tract infection, respectively (1). As in our study ranking of the incidence rates by affected sites was similar to that reported by NNIS system, entitles us to speculate that the predictive positive value of our method to search after cases was quite high.

Interesting to say that our incidence rates are similar with those reported from economically developed states from North America (1, 6) or Europe (7) but dissimilar to those reported from developing countries from South America, were on the top place of the hierarchy by anatomic sites is placed the ventilator associated pneumonia (8,9).

The hospital management's interest to know if the NI rates derived from the own unit are comparable with those reported by other hospitals with a similar profile is entirely justified by the need to ensure the external quality control of the services provided to consumers. Regarding to the quality of IC program, today tendency is substantially orientated toward the standardized, prospective, active surveillance of NI (10, 11). The reason consists in the fact that the results of this approach are suggesting to policy makers, in an explicitly and persuasively manner, the nature of the correction strategies capable to effectively decrease the NI associated hospital morbidity and mortality (7) and even more the efficiency of these strategies after implementation (12).

In operational terms the decedent aiming to "reenter in normality" (i.e. bringing the value of the own rate within the interval qualified as normal or "expected"), had to select the necessary, affordable, and feasible measures which will effectively alter (either to rise or to decrease) the value of one of the two terms of the concerning rate calculation fraction. For instance in our case the options that can be contemplated in order to increase MID underutilization rate should be as follows:

a) Numerator augmentation (i.e. number of patient-days exposed to MID); obviously this option cannot be taken in consideration because in real practice it is not possible to prescribe a MID without a strong medical indication in hand;

b) Decreasing the denominator: this option remains the unique solution to afford for; we must say that a crystal clear understanding of the meaning of the value which must be mitigated (number of exposure days), will allow for sketching strategic options like the follows: (a) discharging patient from PICU immediately after ceasing the medical indication to be treated in this unit or/and (b) abstaining from admitting in PICU of patients without having a sustained medical indication (and not one based on traditional behaviors) to be carried after in this unit. It is our strong perception that underutilization of the mechanical ventilator and the central lines found in our data set derived from the local practice of admitting in PICU of those patients mostly needing a short period of time of enhanced surveillance rather then invasive

sustaining of failed biological functions/systems. In mathematical terms this practice clearly "inflated" the denominators (i.e. cumulative number of days spent in PICU) and consecutively decreased the value of MID utilization rates. However, we had to emphasize that this undesirable outcome was impossible to avoid (e.g. by excluding short PICU-journey patients from study cohort) without altering the CDC genuine method used for raw data's harvesting, method which is based on daily census of the PICU patients and not on a retrospective review of patients' medical charts.

Now related to incidence rates suggesting underreporting of nosocomial infection, the alternatives to be manipulated should be as following:

a) Increasing the numerator value (i.e. number of NI cases): in theory, this strategy can be considered (solution: more effective case detecting) in those units where the nosocomial infection are passively surveyed, knowing that the reported sensitivity of this type of surveillance is only 30%-40% high (13). However, taken alone, this option is apparently unjustified in our case in which the surveillance was an active one. Focusing on the comparatively low rate of urinary catheter related NI detected in our unit (our case) we can speculate that some cases might be missed because, in contrast with adult patient, small children are less prone to report the specific symptoms of a symptomatic urinary tract infection. In this case potentially a proactive policy of "asymptomatic" bacteriuria is detected in patients with indwelling urinary catheters, involving routine bacteriological testing of urine samples, may be an effective solution for increasing the infection rate numerator.

b) decreasing the denominator value (i.e. patient-days exposed to MID): decreasing the number of MID exposure days seems to be the most attractive option which practically implies: (a) instantly "MID weaning" when the medical evidences impose this movement (e.g. when the patient's supported biological functions were regained) and/or ordering of MID utilization on a strictly individual base, and not as a routine, general rule (14,15,16,17,18,19).

Finally the infection rates classified as high (when compared with expected distribution) unequivocally urges the implementation of measures focused on cutting the number of cases in excess, the nature of these measures being similar to interventions recommended for controlling (interrupting of transmission) of a true epidemic episode (20). For instance in our clinic the main measures scheduled as the reaction to a cluster of bloodstream infections includes (without being limitative) the following interventions: training/retraining of the concerned staff regarding the good medical practices (hand hygiene, aseptic inserting, accessing and care of the invasive vascular devices, proper intervals for vascular catheters and infusion sets replacing, proper policies for blood, lipids and TPN administering, proper parentheral multidose vials/bags medications policy), enhanced surveillance and feed-backing of the surveillance results to clinicians.

Comment: it is our understanding that the managerial decision to implement standardized prospective surveillance is not easy to take, as this implies allocation of competent and dedicated human resources provided with adequate logistic (mainly IT equipments) (21), but the advantages of this option are primordially of managerial nature as the surveillance results represents heavy objective evidences suggesting the most comprehensive ways for decreasing of hospital morbidity, mortality, and their associated health costs (22).

CONCLUSION

- This study demonstrated both the feasibility and also the opportunity of the integration of the NI standardized prospective surveillance into the Romanian hospitals' routine practice, provided that the IC team has the competent human resources, basic logistics and is effectively sustained by the hospital management;
- Estimation of standardized incidence and utilization rates, comparable with a reference system, allows for formulation or revision of the local medical/nursing practice rules (house rules) based on medical evidences, preventing in so far improvisations and discretionary;
- NI rates observed in our unit are reasonably fitted into expected distributions which are reflecting the status of the US correspondent service. The existing differences between our utilization rates and the expected ones are merely reflecting the local rules then true deviations from standards of medical practice. To this end we are confident that the comparatively

low MID utilization rates found in our data set is entirely reflecting the peculiar specificities of our PICU, namely: (a) a unique facility serving a multidisciplinary, busy clinic and (b) a local policy to avoid using central vascular lines for invasive monitoring of vital functions only, etc. Under the above circumstances, the MID utilization rates estimated either in 2005 or in 2006 were consistently similar.

LIMITS

Based on our best knowledge, the present study is the first in Romania using the NNIS system methodology for assessing the devices utilization and device associated NI incidence rates; for this reason, the great limit of this study is the impossibility to use our data for quality control through national comparisons.

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