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Prognostication of probable lethality terms for victims with closed intra-abdominal polytrauma using the MODS-II scale

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Summary. The randomized simultaneous retrospective study of results obtained following the treatment of 119 victims with closed abdominal polytrauma has determined the value of abdominal perfusion pressure index as a functionally significant predictor clarifying the beginning of the organic dysfunction development in victims. Qualimetric evaluation of victim condition severity using the MODS-II scale and the index of abdominal perfusion pressure permits to determine the terms of probable lethality already during the early hospitalization stage.

Keywords: abdominal trauma, abdominal perfusion pressure (APP), MODS-II scale, polyorganic deficiency syndrome (PODS).

INTRODUCTION

During last decades the polytraumas were found in 8.0–30.0 % of different traumatic accidents covering up to 70.0 % of lethal cases [2]. The main factors determining the results of injury are trauma severity as well as manifestations of polyorganic dysfunctions in victims [1]. In some European states the reformation of the emergent health care system aiming to abolish vital dysfunctions already during the early hospitalization stage has guaranteed the decrease of road traffic trauma-caused lethality by several times [4]. That is why, proceeding from some certain criteria elaborated by the evidential medicine, a series of standardized estimation systems (SES) have been introduced to the medical practice permitting the impartial evaluation of the victim condition and trauma severity as well as the prediction to the certain degree of the next traumatic process course [3].

Among SES, the special role belongs to scales intended for dynamic evaluation of organic dysfunction severity during the victim postoperative treatment, such as SOFA, APACHE-II, SAPS-II, MODS-II [5]. However, the shortcomings of these scales are their limited possibilities: these scales may facilitate only the determination of lethality and bed-day quantity required for victims in departments of resuscitation and intensive care (DRIC) or risk of hospital lethality (in percents). The data mentioned above suggest the worth of improvement of the current MODS-II scale taking into consideration the index of abdominal perfusion pressure (APP) as a functionally significant predictor clarifying the beginning of the organic dysfunction development in victims.

OBJECT OF INVESTIGATION

To determine the diagnostic value of abdominal perfusion pressure for the prognostication of probable victim lethality terms aiming to ground the choice of differential surgical tactics for «damage control».

MATERIALS AND METHODS OF THIS RESEARCH

The authors have analyzed the consequences of treatment for 119 victims with closed abdominal polytraumas; the patients were divided into two groups, the first group including the cured (n = 62) and the second one – the deceased persons (n = 57). All the victims were operated and stayed for treatment in the Polytrauma Department of the Kyiv City Clinical Hospital providing the urgent health care during the period from 2010 up to 2012. The qualimetric evaluation of victims' condition was carried out using the MODS-II scale, the index of abdominal perfusion pressure (APP) having been included to this scale in our studies. It was determined as the difference between the average value of arterial pressure (AP_{AV}) and intra-abdominal pressure (IAP). To evaluate the IAP degree, the classification of D. Meldrum et al. (1997) was used; according to this classification, the first, second, third, and forth IAP degrees correspond to 10–15, 15–25, 25–35, and > 35 mm Hg, respectively [6]. The IAP measurement was carried out by the bladder catheterization [7].

To ascertain the statistical dependence between functional indices obtained using the MODS-II scale and the APP index, correlation analysis was made according to Pearson (r_p), the dependence strength having been determined by the Chertok's approach. The prognostication of victim lethality terms based on calculations using the MODS-II scale and determination of the APP index were carried out by the aid of multiple regression equation and Kramer's formula. The evaluation of statistical significance of multiple regression equation was made using the Fisher's F-criterion, when $F_{actual} > F_{crit.}$, the p value being < 0.01. To determine the calculating capacities of different scales, regression analysis was carried out based on calculations of binary logistic regression models (AUROC analysis); in such a way receiver operator curves (ROC) were modeled and the areas under the curves (AUC) were estimated (AUC_{MODS}-indices, AUC ± SE, where SE is the standard error).

The data obtained were verified using the software package STATISTICA 8.0 (StatSoft Inc.,USA, 2007).

RESULTS AND DISCUSSION

According to our data, the average index of actual lethality term in the group of victims deceased achieves 4,6 ± 1,2 ($CI_{95\%}$ 3.2−6.1) days, the average index calculated according to the MODS scale and average APP index being 15 ± 1 ($CI_{95\%}$ 14−16) points and 42 ± 3 ($CI_{95\%}$ 37−48) mm Hg, respectively (see Table 1).

Table 1

Indices of early hospital stage in victims and estimation of different scales prognostic value according to the AUROC-analysis data

Indices	Cured victims (n = 62)		Deceased victims (n = 57)	
	M ± m	CI$_{95\%}$	M ± m	CI$_{95\%}$
Actual lethality term (bed-day quantity)	19.6 ± 0.7	18.3–21.0	4.6 ± 1.2	3.2–6.1
APP (mm Hg)	62 ± 2	59–65	42 ± 3	37–48
MODS-II (points)	11 ± 1	10–12	15 ± 1	14–16
AUC$_{MODSs-II}$-index; SE and p values	0.718 ± 0.05; p = 0.021			
MODS-N (points)	13 ± 1	12–14	17 ± 1	16–18
AUC$_{MODSs-II}$-index; SE and p values	0.763 ± 0.04; p = 0.001			
Prognosticated lethality term (bed-day quantity)	19.6 ± 0.6	18.3–20.7	4.7 ± 1.0	3.8–5.7
Fisher's F-criterion: F$_{crit.}$ = 3.15, p < 0.01	F$_{actual}$ = 104.54		F$_{actual}$ = 25.94	

In the group of cured patients the average bed-day quantity index is 19.6 ± 0.7 (CI$_{95\%}$ 18.3–21.0), the average index calculated according to the MODS-II scale and the average APP index being 11 ± 1 (CI$_{95\%}$ 10–12) points and 62 ± 2 (CI$_{95\%}$ 59–65) mm Hg, respectively.

Thus, using of the scale for dynamical evaluation of the organic dysfunction severity in the randomized victim massive we have determined the average dependence strength between the APP index and the index obtained according to the MODS-II scale (r_p = –0,59) as well as the index of actual lethality term (r_p = –0,63) in the group of deceased victims, this dependence strength being high (r_p = 0,88) in the group of cured persons. Proceeding from these data and using the Kramer's formula as well as the MODS-II scale and the APP index, it is possible to calculate the victim's lethality term according to the multiple regression formula № 1 or the recommended bed-day quantity for a victim with closed abdominal polytrauma according to the formula № 2:

$$Y_1 = 23.02 - 0.97 \times X_1 + 0.087 \times X_2 \ (1),$$
$$Y_2 = 6.46 + 1.3 \times X_1 - 0.023 \times X_2 \ (2),$$

where: $Y_{1,2}$ are terms of prognosticated lethality or quantity of bed-days, X_1 is the index found using the points according to the MODS-II scale, and X_2 is the APP index (mm Hg). From the prognostic point of view, it is necessary to use both formulae for calculations. To facilitate these calculations, a nomogram is proposed here permitting to measure prognosticated lethality terms or quantity of bed-days (Y, days) in limits of the confidence interval (p < 0.05, or 0.05 < p < 0.1), comparing X_1 and X_2 indices (Y, day) (see Figure 1).

Both trends describing the dependence of actual lethality terms of victims deceased or quantity of bed-days for cured patients on the index obtained using the MODS-II scale and the APP index suggest the statistical significance

of the multiple regression formula № 1 (F_{actual} = 25.94, $F_{crit.}$ = 3.15, p < 0.01) and of the formula № 2 (F_{actual} = 104.54, $F_{crit.}$ = 3.15, p < 0.01).

To improve the current MODS-II scale taking into consideration the APP index, we have elaborated its gradation from 0 to 3 points. These calculations were carried out based on the confidence interval for minimal APP index values ($CI_{95\%}$ min is 37) and IAP levels ($CI_{95\%}$ min is 17) corresponding to the 2nd victim condition severity taking into consideration the value of kidney perfusion pressure. So, 0 point, 1 point, 2 points, and 3 points correspond to APP indices ≤ 81, 66–80, 35–65, and ≤ 34 mm Hg, respectively.
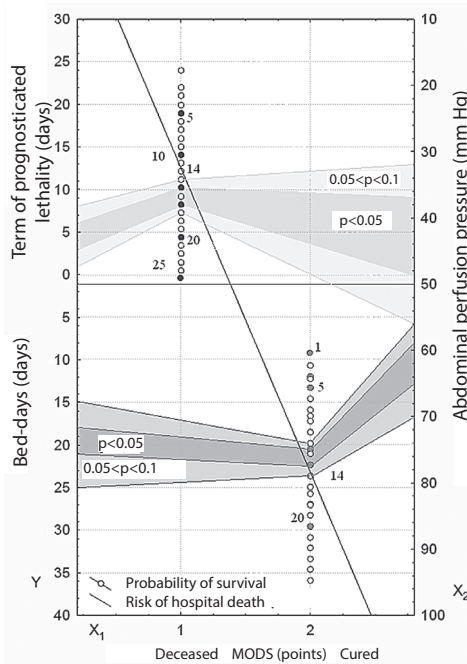
Figure 1
Nomogram of prognosticated lethality term or recommended bed-day quantity (Y) dependence on the index obtained using the MODS-II scale (X_1) and abdominal perfusion pressure index (X_2)

The following qualimetric estimation of victim's condition severity degree was carried out depending on point quantity obtained using the experimental MODS-N scale being a sum of points determined with the MODS-II and the APP index. Taking into account the point quantity according to the experimental MODS-N scale (see the first column of the Table 2), the severity degree of the victim condition, prognosis for life and refinement of hospital death risk (%) may be made (see Table 2). Further, proceeding from the estimation of patient's postoperative organic dysfuction severity, the terms of prognosticated lethality or quantity of bed-days may be determined and refined using the formulae № 1 and № 2.

Table 2
Estimation of victim condition severity and prognostication of probable lethality of patients with closed abdominal polytrauma using the MODS-N scale

| Points according to the MODS-N scale	Severity degree of the victim condition, prognosis for life	Risk of hospital death (%)	Terms of progno-sticated lethality	Quantity of bed-days
1–4	First severity degree. Prognosis favorable for life, the lethality may be caused by other complications of wound dystrophy.	2–3	–	< 10
5–8		5–11	> 26	10–15
9–12	Second severity degree. Doubtful prognosis for life, high probability of polyorganic deficiency syndrome and of wound dystrophy	18–26	11–20	15–23
13–16		28–44	7–17	20–26
17–20	Third severity degree. Prognosis unfavorable for life, high probability of death during the shock period	53–82	3–14	27–32
21—24		91–96	1–10	> 32
> 25	Injury incompatible with life, high probability of death within 24 h	100	1	—

To compare calculative powers of MODS-II and MODS-N scales concerning their prognostication of probable lethality terms, the AUROC-analysis has been carried out modeling characteristic ROC-curves with evaluation of the AUC-index.

Using the MOD-II scale, the prognostic value of the ROC-II curve obtained reaches 71.8 % ($AUC_{MODS-II}$ 0.718 ± 0.047; p = 0.021) comparing to its value found with the experimental scale MODS-N whose prognostic value is significantly higher – 76.3 % (AUC_{MODS-N} 0.763 ± 0.044; p = 0.001) (see Figures 2 and 3).

ROC Curve MODS

p = .0215
AUC = .7177
SE = .0472

1 – Specificity
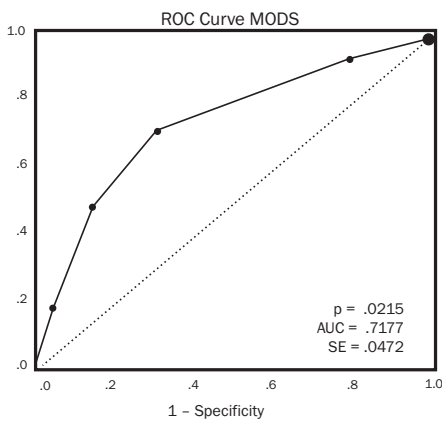
Figure 2
Characteristic ROC-curve evaluating the index of area under curve according to the MODS-II scale in the randomized massive of victims deceased and cured

ROC Curve MODS-N

p = .001
AUC = .7627
SE = .0442

1 – Specificity
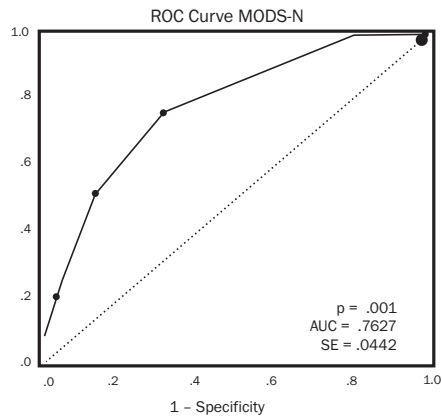
Figure 3
Characteristic ROC-curve evaluating the index of area under curve according to the MODS-N scale in the randomized massive of victims deceased and cured

The mode of probable lethality prognostication described in our application is illustrated by the clinical algorithm of our useful model (Figure 4). It is simple, requires no expensive equipment and should be introduced into research practice and statistics departments for lethality analysis.
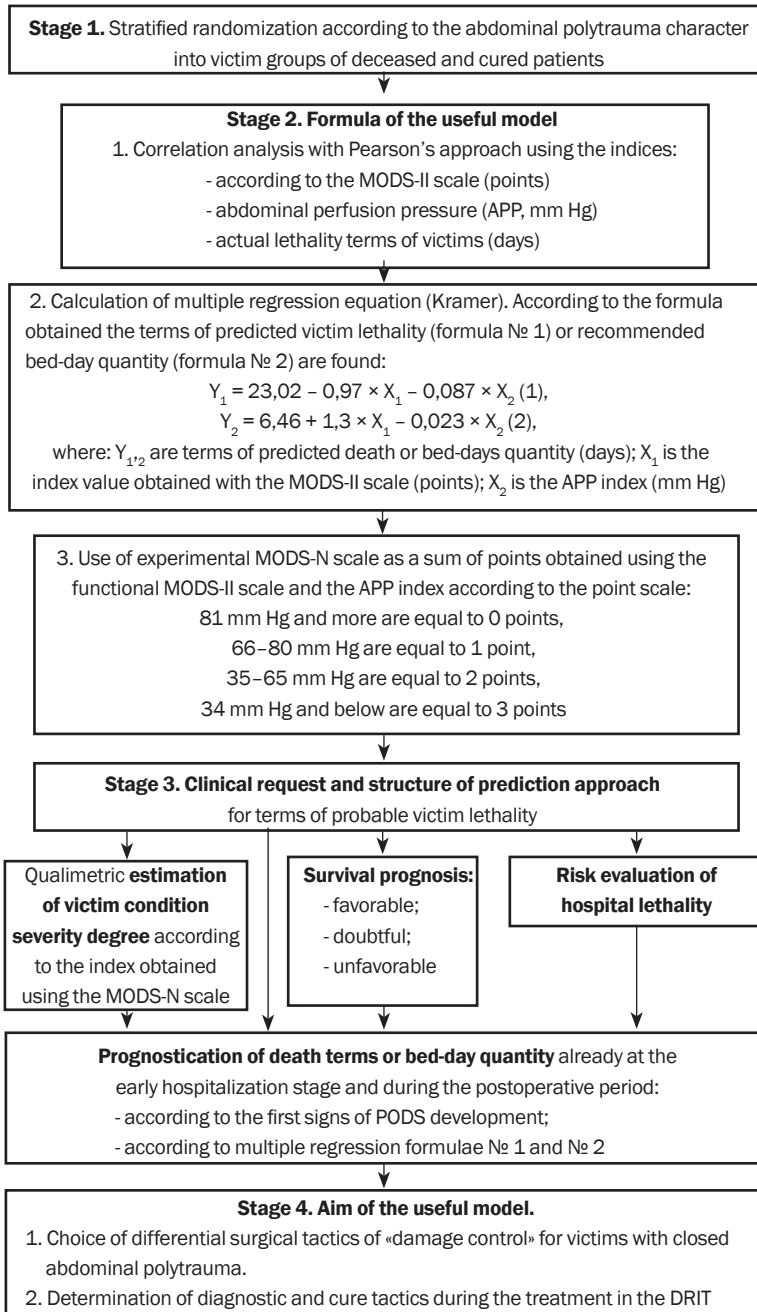
Stage 1. Stratified randomization according to the abdominal polytrauma character into victim groups of deceased and cured patients

Stage 2. Formula of the useful model
1. Correlation analysis with Pearson's approach using the indices:
- according to the MODS-II scale (points)
- abdominal perfusion pressure (APP, mm Hg)
- actual lethality terms of victims (days)

2. Calculation of multiple regression equation (Kramer). According to the formula obtained the terms of predicted victim lethality (formula № 1) or recommended bed-day quantity (formula № 2) are found:
$$Y_1 = 23{,}02 - 0{,}97 \times X_1 - 0{,}087 \times X_2 \ (1),$$
$$Y_2 = 6{,}46 + 1{,}3 \times X_1 - 0{,}023 \times X_2 \ (2),$$
where: $Y_{1,2}$ are terms of predicted death or bed-days quantity (days); X_1 is the index value obtained with the MODS-II scale (points); X_2 is the APP index (mm Hg)

3. Use of experimental MODS-N scale as a sum of points obtained using the functional MODS-II scale and the APP index according to the point scale:
81 mm Hg and more are equal to 0 points,
66–80 mm Hg are equal to 1 point,
35–65 mm Hg are equal to 2 points,
34 mm Hg and below are equal to 3 points

Stage 3. Clinical request and structure of prediction approach
for terms of probable victim lethality

Qualimetric **estimation of victim condition severity degree** according to the index obtained using the MODS-N scale

Survival prognosis:
- favorable;
- doubtful;
- unfavorable

Risk evaluation of hospital lethality

Prognostication of death terms or bed-day quantity already at the early hospitalization stage and during the postoperative period:
- according to the first signs of PODS development;
- according to multiple regression formulae № 1 and № 2

Stage 4. Aim of the useful model.
1. Choice of differential surgical tactics of «damage control» for victims with closed abdominal polytrauma.
2. Determination of diagnostic and cure tactics during the treatment in the DRIT

Figure 4. Clinical algorithm of the useful model

Thus, the use of the MODS-II scale taking into account the APP index in victims with closed abdominal polytrauma permits to determine the victim severity degree and to predict the lethality terms already during the early hospitalization stage permitting to ground the choice of differential surgical tactics of «damage control» as well as postoperative victim patient management in the DRIC.

CONCLUSIONS

1. The use of experimental MODS-N scale is possible in clinical practice to carry out the dynamic evaluation of organ dysfunction for victims with closed abdominal polytrauma being treated in the DRIC.

2. The prognostication of probable lethality terms based on the use of the MODS-II scale and the index of abdominal perfusion pressure in victims is necessary for grounding of differential surgical tactics of «damage control».

3. The drop of the abdominal perfusion pressure below 80 mm Hg should be considered as a highly important factor indicating the beginning of the organ dysfunction development in the course of traumatic process.

4. The decrease of the abdominal perfusion pressure below 65 mm Hg indicates the development of abdominal hypertension syndrome accompanied by the damage of kidney perfusion pressure; these phenomena correspond to the 2nd condition severity degree of the victim according to the experimental MODS-N scale.

Прогнозування терміну вірогідної летальності при застосуванні шкали MODS-II у постраждалих з поєднаною закритою абдомінальною травмою

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Резюме. На основі рандомізованого одночасного ретроспективного дослідження результатів лікування 119 постраждалих з поєднаною закритою абдомінальною травмою встановлена діагностична цінність показника абдомінального перфузійного тиску як функціонально-значимого предиктора початку розвитку органної дисфункції. Кваліметрична оцінка тяжкості стану постраждалих із застосуванням шкали MODS-II і показника абдомінального перфузійного тиску дає можливість встановити термін вірогідної летальності вже на ранньому госпітальному етапі.

Ключові слова: абдомінальна травма, абдомінальний перфузійний тиск, шкала MODS-II.

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