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RE: manuscript # 8520

TO THE EDITOR IN CHIEF

Dear A. Jay Block, MD, FCCP

We made the final revision of our manuscript entitled "NEAR-DROWNING AND DROWNING CLASSIFICATION: A proposal to stratify mortality based on the analysis of 1,831 cases", # 8520, in accordance with yours reviewers, and responded to each comment point by point.

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TITLE: **NEAR-DROWNING AND DROWNING CLASSIFICATION: A proposal to stratify mortality based on the analysis of 1,831 cases.**

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TITLE: NEAR-DROWNING AND DROWNING CLASSIFICATION: A PROPOSAL TO STRATIFY MORTALITY BASED ON THE ANALYSIS OF 1,831 CASES.

ABSTRACT

Study objective: To establish an updated classification for near-drowning and drowning(ND/D) according to severity, based on mortality rate of the subgroups.

Materials and Methods: We reviewed 41,279 cases of predominantly sea water rescues from the coastal area of Rio de Janeiro City, Brazil, from 1972 to 1991. Of this total, **2,304 cases (5.5%)** were referred to the Near-Drowning Recuperation Center, and this group was used as the study data base. At the accident site the following *clinical parameters* were recorded: presence of breathing, arterial pulse, pulmonary auscultation, and arterial blood pressure. Cases lacking records of *clinical parameters* were not studied. The ND/D were classified in 6 subgroups: **Grade 1** - *Normal pulmonary auscultation with coughing;* **Grade 2** - *Abnormal pulmonary auscultation with rales in some pulmonary fields;* **Grade 3** - *Pulmonary auscultation of acute pulmonary edema without arterial hypotension;* **Grade 4** - *Pulmonary auscultation of acute pulmonary edema with arterial hypotension;* **Grade 5** - *Isolated respiratory arrest;* **Grade 6** - *Cardiopulmonary Arrest(CPA).*

Results: From 2,304 cases in the data base, 1,831 cases presented all clinical parameters recorded and were

selected for classification. From these 1,831 cases, 1,189(65%) were classified as Grade 1 (mortality = 0%); 338(18.4%) as Grade 2 (mortality = 0.6%); 58(3.2%) as Grade 3 (mortality = 5.2%); 36(2%) as Grade 4 (mortality = 19.4%); 25(1.4%) as Grade 5 (mortality = 44%); and 185(10%) as Grade 6 (mortality = 93%)(P<0.000001).

Conclusion: The study revealed that it is possible to establish 6 subgroups based on mortality rate by applying clinical criteria obtained from first-aid observations. These subgroups constitute the basis of a new classification.

NDRC - Near-Drowning Recuperation Center.
CPA - Cardiopulmonary Arrest.
CPR - Cardiopulmonary Resuscitation.
ARA - Absence of Respiratory Assistance.
NIRA - Non-Invasive Respiratory Assistance.
IRA - Invasive Respiratory Assistance.
BRA - Both Respiratory Assistance(NIRA and IRA).
SBP - Systolic Blood Pressure.
ND/D - Near-Drowning and/or Drowning

Keywords: Near-Drowning, Drowning, Classification, CardioPulmonary Arrest, Cardiopulmonary Resuscitation, Acute Respiratory Failure, Prognosis, Mortality.

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INTRODUCTION

Brazil has the longest coastal strip in South America(7,408 km [4,445 mile]). Its warm climate encourages a beach-going culture year round. In 1990 the Brazilian population reached 150 million people, of whom 7,111($4.7/10^5$ population) died due to drowning (1). Rio de Janeiro city has a rescue service responsible for safety along 96 km of beaches, with 2 lifeguards every 500 m. and specialized medical teams in 3 different care centers called Near-Drowning Recuperation Centers (NDRC). The duty of the NDRCs is to render specialized medical assistance to ND/D patients, brought in promptly from accident sites. The patients stays on NDRC until clinical stabilization is achieved, allowing their release, further observation, or referral to a hospital (2). There has been difficulties in predicting the prognosis of such patients, because a classification system was lacking. In 1972, Menezes and Costa proposed a classification dividing the cases of ND/D into 4 grades of severity: Grade I showed normal pulmonary auscultation; Grade II showed rales in both pulmonary bases; Grade III showed acute pulmonary edema; and Grade IV were cases of CPA. The mortality rate was, Grade I = 0.0%, Grade II = 0.6%, Grade III = 10.6% and Grade IV = 87.1%(3).

This study was implemented with the purpose of re-evaluating the Menezes and Costa classification and updating it with other clinical parameters to evaluate the severity of the ND/D.

MATERIAL and METHODS

Area and population Researched

We retrospectively reviewed 41,279 cases of predominantly sea water rescues, utilizing rescue bulletins recorded by lifeguards on the beach, from January 1972 to December 1991. These cases were observed in a restricted sample area of 22 km which falls under the authority of the Rio de Janeiro rescue service, and which constitutes 23% of the total coastal area of Rio de Janeiro City. From this population, 2,304 cases (5.5%) were referred to the NDRC during the study period because they had been diagnosed as ND/D requiring medical attention. The remaining 38,975 cases did not require further medical care and were released directly from the site of the accident after lifeguards had filled out a beach rescue bulletin. The medical aid bulletin filled out at the NDRC describes the occurrences prior to the physician's arrival based on a detailed report compiled by the lifeguard responsible for first aid, as well as the subsequent medical treatment; data were compiled until the patient was discharged from the NDRC or died. In addition, those

patients requiring transfer to a hospital had their hospital records reviewed.

One water characteristic were considered important to final analysis: Sea water temperature throughout the year in the study area varies from 15°C to 25°C, with an average of 20°C(68^0F).

Initial management of the Near-Drowning and Drowning(ND/D)

A case was considered a *rescue case* (without near-drowning diagnosis) when the bather presented normal pulmonary auscultation without coughing. Any case of rescue involving altered pulmonary auscultatory findings and/or coughing was considered as water aspiration (*near-drowning*), and received immediate medical care on the beach.

A physician with experience in this type of accident was always present during first aid on the beach in near-drowning cases and was in charge of filling out the medical bulletins of the NDRC. The physician was contacted by the lifeguard via radio immediately after the water rescue had taken place and near-drowning was diagnosed. In our system, lifeguards are responsible for initial evaluation of the presence of breathing and arterial pulse, as well as applying, if necessary, basic cardio-pulmonary resuscitation until the medical team arrives. The medical team responds via an

ambulance equipped with ECG monitor, defibrillator, and medication and ventilation equipment. Medical examination at the scene of the accident covers presence of breathing and arterial pulse, pulmonary auscultatory findings, measurement of blood pressure and heart rate, determination of the level of consciousness, the need for respiratory assistance, and the type of respiratory assistance required. This medical examination and treatment are continuously reassessed and changed, as necessary, during transportation to the NDRC.

Clinical parameters evaluated

For the purpose of classifying the ND/D the data utilized were those obtained by the physician during initial examination.

Pulmonary auscultation was classified into 3 types:

1. Normal pulmonary auscultation with coughing.
2. Abnormal pulmonary auscultation with rales in some pulmonary fields.
3. Abnormal pulmonary auscultation with rales in all pulmonary fields (acute pulmonary edema).

Blood pressure was used to classify the ND/D as normotensive or hypotensive. In infants and children less than or equal to 9 years of age, hypotension was defined as systolic blood pressure(SBP) less than the minimum systolic pressure calculated by the following

formula: 70 + (2 x age in years)(4). Individuals older than 9 years of age were considered similar to adults, and thus hypotensive when the systolic blood pressure was less than 90 mmHg (5), or the mean arterial pressure (MAP) less than 60 mmHg calculated by the following formula:

$$\frac{2 \times \text{diastolic blood pressure} + \text{SBP}}{3}$$ (6).

Isolated Respiratory Arrest (Apnea) was considered present when spontaneous breathing or pulmonary ventilation was absent, but arterial pulse present.

Cardio-Pulmonary Arrest (CPA) was defined as the absence of carotid arterial pulse and spontaneous pulmonary ventilation.

We excluded from the study the ND/D cases for which clinical parameters had not been recorded in the bulletins upon first examination, as well as cardio-pulmonary arrest cases in which no Cardio-Pulmonary Resuscitation (CPR) attempts were performed (generally in cases where the submersion time had been longer than 1 hour), and ND/D cases secondary to other pathologies(secondary ND/D).

The use of alcohol was considered a major factor in causing secondary ND/D, when ethanol ingestion was reported by the family or friends in sufficient quantities to alter the judgment in situations of danger, or when the estimated ingestion had been over

[56 grams] on the day of the accident. These cases were also excluded from the study data base.

In addition to the above mentioned clinical data, respiratory assistance needs and level of consciousness were analyzed. The *Respiratory Assistance Need was* classified in accordance with the presence or absence of respiratory failure in 3 different subgroups, as follows: 1. Absence *of Respiratory Assistance* need(ARA); 2. *Non-Invasive Respiratory Assistance* need(NIRA) using oxygen catheter or mask; 3. *Invasive Respiratory Assistance* need(IRA) using mechanical ventilation. The *Respiratory Assistance Need* was based upon clinical judgment and influenced by respiratory effort and respiratory rate. *Level of consciousness* was divided into 4 categories: 1. *Lucid* when the individual was awake, capable of correctly communicating what had happened to her/him; 2. *Confused State*, when the individual was awake but not capable of communicating correctly about the accident; 3. *Stupor* in cases of extreme drowsiness with little or no spontaneous activity, and response only to strong verbal or painful stimulation; and 4. *Coma* in which the most intense stimulation does not produce verbal or awakening responses and the victim remains unconscious. The Glasgow Coma Scale was not used because some data were unavailable resultant to the retrospective nature of this study.

For the purposes of stratifying the patients into different risk subgroups, the following classification was used, taking into account initially obtained data concerning cardio-pulmonary conditions, pulmonary auscultation, and arterial blood pressure.

GRADE 1 - *Normal pulmonary auscultation with coughing.*

GRADE 2 – *Abnormal pulmonary auscultation with rales in some pulmonary fields.*

GRADE 3 - *Abnormal pulmonary auscultation with rales in all pulmonary fields (acute pulmonary edema)* ***without*** *arterial hypotension.*

GRADE 4 – *Abnormal pulmonary auscultation with rales in all pulmonary fields (acute pulmonary edema)* ***with*** *arterial hypotension.*

GRADE 5 – *Respiratory Arrest (Apnea) without cardiac arrest.*

GRADE 6 – *Cardio-Pulmonary Arrest* (CPA).

Statistical Analysis

The clinical parameters for the evaluation of the ND/D patients were analyzed in a univariate form with respect to their relation to mortality through simple tables by the 'Mantel-Haenszel' method. The X^2 and the value of P were evaluated. $P < 0.05$ (95% confidence limit) was considered to be of statistical significance (7).

RESULTS

Population surveyed

From 2,304 cases of ND/D referred to the NDRC because they required medical assistance, 92.6%(2,134 cases) were rescued from water by lifeguards and 7.4%(170 cases) by bathers present at the accident site (including all fresh water cases). All cases attended on the beach by an ambulance with the medical team, had an average response time of 12.3 +/-5.8 minutes. Of those sea water ND/D patients(2,274 cases), 90% were brought by ambulance and the rest (10%) were taken to the NDRC by citizens in private cars, or helicopter. Although lifeguards were not present at all rescues, they were always present during subsequent first aid, except in cases of ND/D in fresh water. The mortality rate of 2,274 sea water cases was 12.3%, while the 30 fresh water cases had a mortality of 16.7% (P = NS). The demographics of the 2,304 ND/D patients covered by this study are shown in Table 1.

In none of 2,304 cases were specific therapeutic measures implemented concerning brain protection or brain resuscitation. There was hypothermia (body temperature <35°C or <95°F) in all of the 532 cases in which the axillary temperature was recorded in the medical assistance bulletins.

Secondary ND/D (associated with another pathology) that might have triggered or precipitated the accident were observed in 276 cases of 2,126 ND/D cases in which this parameter was documented. The mortality of this group was 13.4%. The most frequent cause of secondary ND/D was the use of drugs (36.2%), most frequently alcohol, followed by seizures (18.1%), trauma (16.3%), cardio-pulmonary disease (14.1%), subaquatic activities(3.7%) and others (11.6%).

Of 2,304 cases surveyed, 473 were excluded: 162 due to the lack of one or more recorded clinical parameters (no deaths and 19 were cases of secondary ND/D), 65 CPA cases without resuscitation attempts (all were considered dead {11 secondary drowning}), and 246 cases of secondary drowning (26 deaths).

The remaining 1,831 cases constitute the population analyzed for our classification system.

Classification

The classification being proposed is based upon the 1,831 selected cases which demonstrated different

mortalities among each ND/D grade evaluated (X^2=1529.20, P<0.00001)(Table 2).

Follow-up evaluation from the accident site to hospital discharge or death

All 1,831 cases were at least initially treated at the NDRC, but 187 patients required transfer to a hospital (Table 3). Mortality for the entire group was 10.6% (195 cases, of which 166 died at NDRC and 29 in the hospital).

Other clinical parameters

The need for respiratory assistance was documented in 1,828 cases. Analyzing the different types of respiratory assistance we observed that Grade 1 is characterized by ARA in 86.3% of cases, and in Grade 2 the need for NIRA prevailed (93.2%)(X^2=793.54, P<0.00001). Grade 3 patients used either IRA(72.4%) or NIRA(27.6%), and grades 4, 5 and 6 used IRA in 100% of cases.

The level of consciousness was recorded in 1,662 cases showing different mortality rates (P<0.00001). However, when we evaluated the ND/D grades with different levels of consciousness(Table 4), only Grade 2 showed greater mortality rate(10%), and this occurred when stupor was present (X^2=9.20, P<0.003).

DISCUSSION

The idea of updating the classification we previously used derived from the observation of cases in which some clinical parameters - acute pulmonary edema with hypotension and apnea without cardiac arrest - seemed to stratify into subgroups with different mortality rates. These observations were the impetus for a retrospective survey that demonstrated the validity of analyzing each clinical parameter, dividing cases of ND/D into 6 different grades of severity according to an initial examination.

From the total of 2,304 cases evaluated, the new classification was based on 1,831 cases that presented a mortality rate of 10.6% (195 cases). Cases of secondary near-drowning (which were excluded from this

study) did not have significant differences in mortality as compared to the group included in the final analysis.

Considering those six clinical parameters mentioned above we suggest a new classification for ND/D.

Grade 1 - patients who aspirate a small amount of water, sufficient to provoke irritation of the upper airways causing *Normal pulmonary auscultation with coughing*. The amount of water penetrating the airways is not sufficient to cause alteration in alveolo-capillary gas exchange requiring medical intervention.

Grade 2 - patients who aspirate a moderate amount of water, sufficient to alter pulmonary alveolo-capillary gas exchange causing *Abnormal pulmonary auscultation with rales in some pulmonary fields.* Generally these patients require NIRA (93.2%). Nevertheless, 1.8% of cases needed IRA, and mortality rate was greater in these($P<0.00001$). These data raise the possibility of substratifying this Grade into 2 types (A and B) with different mortality rates. This, however, is only feasible after some hours of evaluation and not upon first examination. Adult Respiratory Distress Syndrome (ARDS)sometimes caused by ND/D, possibly complicated these cases.

Grades 3 and 4 aspirated an amount of water sufficient to cause a significant alveolo-capillary gas exchange alteration as well as a high degree of pulmonary

arterial-venous shunt that generally indicates IRA with early mechanical ventilation and positive end expiratory pressure (PEEP).*Pulmonary auscultation is that of an acute pulmonary edema with rales in all pulmonary fields*, in addition to presenting frequently with pinkish foam in the mouth and nose. They are differentiated from each other(grade 3 from 4) by the hypoxemic period and are therefore subdivided:

Grade 3 - patients with *acute pulmonary edema by auscultation without arterial hypotension*.

Grade 4 - presents with the same pulmonary auscultation as Grade 3 but is associated with *arterial hypotension.* These cases always require IRA and usually remain for a longer period with mechanical ventilatory support. When the patient is not evaluated at the accident scene, oxygen administration may ameliorate the arterial hypotension, leading to an erroneous interpretation with respect to the grade of ND/D. However, as there is no rapid improvement in the level of consciousness with the treatment, the state of coma usually persists. The initial arterial hypotension that occurs in Grade 4 seems to be caused by myocardial depression deriving from hypoxia, as described by Orlowski et al. (8,9), rather than by the transudation of liquid into the lung. The presence of coma may be secondary to a reduction in cerebral blood flow resultant from the hypotension and hypoxia.

Grade 5 - is characterized by the presence of *Respiratory Arrest (Apnea) without cardiac arrest.* Cardiac arrest can, however, occur quickly, in this situation, varying from seconds to 2 or 3 minutes, a phenomenon seen by those working at the accident site. Situations, for example, of "black-out" (which occurs in divers that hyperventilate prior to submerging)(10), are generally reverted very easily, if rescue occurs immediately after the loss of consciousness, as water has not yet been aspirated(11,12).

Grade 6 - These are cases with cardio-pulmonary arrest(CPA), independent of the submersion time. In this study, these CPA cases were diagnosed at the accident site. In general, resuscitation is carried out in all CPA cases when the exact duration of the submersion is not known, or when such time is certainly less than 1 hour. This procedure proved successful in the summer of 1994, when 4 patients were resuscitated after more than 10 minutes water submersion at a temperature above 15°C(59 ^{0}F) (2 died 6 hours later and 2 survived, one with severe neurological sequelae and the other without sequelae).

The recommended new classification algorithm is presented in Figure 1. Once the classification of a particular case has been determined, it should not be changed during the recovery period or hospitalization.

All cases evaluated were followed up from the initial assistance on the beach until their discharge or death, (from NDRC or hospital), allowing accurate determination of mortality rate in each ND/D grade. According to Conn and Modell (13, 14, 15) mortality rate of ND/D can be predicted from the level of consciousness upon first assessment in the hospital emergency room. We consider their data to be of major importance, inasmuch as it shows the degree of anoxic encephalopathy. In our study, 73% of the patients who were in coma at the accident site died. Although this mortality rate is higher than reported in the literature (11, 13, 14, 15, 16, 17, 18) we must remember that our work differs from other studies in that it included assistance and evaluation at the accident site. Among conscious, confused, or stuporous patients (1,473 cases) the mortality rate was 0.5%. It was, unfortunately not possible to substratify the different grades utilizing the evaluated levels of consciousness. Grade 2 patients, however, presenting with stupor upon first examination seem to be prone to higher mortality.

Some authors describe greater severity of pulmonary injury in fresh water ND/D(8, 9, 19). Our fresh water cases did not show a greater mortality than those in sea water, although the group studied was too small to draw any firm conclusions.

CONCLUSION: A new ND/D Classification is suggested, taking into consideration 20 years of NDRC activity, accumulating a total of 1,831 cases for which four clinical parameters (breathing, pulse, pulmonary auscultation, and blood pressure) were reported. These parameters were statistically significant in defining

the classification of six different grades(P<0.00001). If this classification becomes universally accepted, multicenter studies to evaluate the several therapies proposed in the literature(20), but still controversial, could be performed.

The use of NDRC demonstrates that the number of cases requiring hospital referral may be reduced. Although efforts to improve assistance to the near-drowned patient are great, major successes are due to the preventive work of lifeguards at the beaches(early intervention). Brewster quotes the occurrence of 2% to 3% of victim deaths during rescue(21). In 20 years of observation, the victim mortality rate(0.7%) on Rio de Janeiro beaches has been very low as evidence that prevention is indeed the best strategy for this type of accident.

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TABLES AND FIGURE

Table 1 - Demographics.

Table 2 - Number of drowning cases(n) and its mortality. Overall mortality was 10.6%.

Table 3 - Need of hospitalization (10.2%) in Near Drowning/Drowning cases in association with the grade and mortality. Mortality in the hospital was 15.5%; (*)Four patients grade 5 and 162 grade 6, out of this table, were pronounced dead and thus taken directly to the morgue.

Table 4 - Initial consciousness level in all ND/D grades and their mortality. (MORT)Mortality.

Figure 1 - Algorithm - Classification of ND/D (Szpilman 1993)(2). The initials **RPAP** (**R**espiration ⇒ arterial **P**ulse ⇒ pulmonary **A**uscultation ⇒ blood **P**ressure) help memorizing the sequence to follow in assessing the classification.

DEMOGRAPHICS OF THE 2,304 CASEs
Average age was 22.7 +/- 11.5 years(*)

	Percent (%)
Men	74.2
Unmarried	87.4
Reportedly knew how to swim	46.6
Lived far from sea-side	71.4
Alcohol ingestion	14.6
Ate 3 hours prior to the	83.5

(*)5.1% were children less than 9 years

TABLE 1

CLASSIFICATION AND MORTALITY (n = 1831)

GRADE	NUMBER(n)	Mortality
1	1189	0 (0.0%)
2	338	2 (0.6%)
3	58	3 (5.2%)
4	36	7 (19.4%)
5	25	11 (44%)
6	185	172 (93%)
P		< 0.0001

TABLE 2 -

NEED OF HOSPITALIZATION AND MORTALITY (n=187)

GRADE	Hospital(%)	Mortality
1	35(2.9%)	0(0.0%)
2	50(14.8%)	2(4.0%)
3	26(44.8%)	3(11.5%)
4	32(88.9%)	7(19.4%)
5	21(84%)(*)	7(33.3%)
6	23(12.4%)(*)	10(43.5%)
Total	187 (10.2%)	29(15.5%)

TABLE 3 -

CONSCIOUSNESS LEVEL AND MORTALITY (n=1662)

GRADE	LUCID(Mort.)	CONFUSION(Mort.)	TORPOR(Mort.)	COMA(Mort.)
1 (1085)	970 (0)	115 (0)	0 (0)	-----
2 (322)	220 (0)	92 (0)	10 (1)	-----
3 (51)	7 (0)	29 (1)	15 (1)	-----
4 (26)	1 (0)	3 (1)	7 (3)	15 (2)
5 (17)	-----	-----	-----	17 (10)
6 (161)	-----	-----	-----	161 (126)
TOTAL	1198 (0)	239 (2)	32 (5)	193 (138)

TABLE 4