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Neurological outcomes in adult drowning patients in China

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BACKGROUND: Drowning is the third leading cause of unintentional death worldwide. The epidemiological characteristics of adult drownings are rarely reported.

OBJECTIVE: Investigate factors associated with neurological prognosis in adult drowning inpatients.

DESIGN: Multicenter medical record review.

SETTING: Tertiary health care institutions.

PATIENTS AND METHODS: We collected demographic and clinical data on patients who drowned but survived between September 2006 and January 2020. Neurological prognosis was compared in patients with and without cardiac arrest.

MAIN OUTCOME MEASURES: Neurological outcomes.

SAMPLE SIZE AND CHARACTERISTICS: 142 patients with mean age of 50.6 (19.8) years, male/female ratio of 1.54:1.

RESULT: Forty-five patients (31.7%) received CPR, 90 patients (63.4%) experienced unconsciousness, and 59 patients (41.5%) received endotracheal intubation and mechanical ventilation. Multivariate logistic regression analysis showed that the initial blood lactic acid level (OR: 7.67, 95%CI: 1.23-47.82, *P*=.029) was associated with a poor neurological prognosis in patients without cardiac arrest. The incidence of ICU admission (OR: 16.604, 95%CI: 1.15-239.49, *P*=.039) was associated with a poor neurologic prognosis in patients with cardiac arrest.

CONCLUSIONS: For the drowning patients with cardiac arrest, ICU admission was associated with neurological function prognosis in these patients. Among the patients without cardiac arrest, the initial lactate value was associated with neurological function prognosis of these patients.

LIMITATIONS: Retrospective.

CONFLICT OF INTEREST: None.

Drowning is the experience of respiratory impairment from submersion/immersion in liquid.[1] Drowning is the third leading cause of unintentional death worldwide.[2] According to the Global Burden of Disease survey, approximately 60000 people died from unintentional drowning in China in 2016, accounting for 21% of global drowning deaths.[3] The primary outcome of drowning should be classified as death or survival, and neurological impairment is an important outcome scale for assessing the severity of drowning. One study showed that almost 30% of drowning patients required cardiopulmonary resuscitation (CPR).[4] The survival rate of patients after CPR is low; only 10.6% of patients survive to hospital discharge,[5] but the survival rate of drowning patients with cardiac arrest is better than that of other cardiac arrest patients.[6]

The epidemiological characteristics of adult drowning are rarely reported so we retrospectively collected clinical data from three tertiary health care institutions and summarized and analyzed the clinical characteristics and predictors of neurological function prognosis.

PATIENTS AND METHODS

In accordance with the 2015 Revised Utstein-Style Recommended Guidelines for Uniform Reporting of Data from Drowning-Related Resuscitation,[7] we collected data from three tertiary health care institutions for the period from September 2006 to January 2020 (The First Affiliated Hospital of Wenzhou Medical University, The Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University, and Wenzhou Central Hospital). All data were collected from the medical record system and analyzed from the day of admission to the day of discharge. General clinical data, preexisting illness, symptoms and signs, auxiliary examinations, diagnosis, treatment, and survival during hospitalization were analyzed. In terms of drowning-related characteristics, we collected the duration of drowning and wastewater drowning (wastewater specifically refers to rice field water, cement water or factory sewage). We collected data on age, sex, and preexisting illness. The Glasgow coma scale (GCS) score was determined after patients were admitted and discharged. We investigated the initial arterial oxygen saturation and pH. In addition, we collected levels of glucose, serum creatinine and lactic acid. We also checked for pneumonia by lung CT and investigated whether the patients were endotracheally intubated. For patients in the cardiac arrest group, bystander CPR, duration of CPR and restoration of spontaneous circulation (ROSC) after CPR were evaluated. The neurological function of drowning patients was assessed using the cerebral performance category (CPC) score.[8] CPC scores of 1 and 2 represent good neurological outcomes, and CPC scores of 3 and 5 represent poor neurological outcomes.

Data were recorded and analyzed using IBM SPSS (Armonk, New York, United States: IBM Corp) version 21. Data were dichotomized into good and poor neurological outcomes. Normal distributions are presented as percentages and the mean (standard deviation). Data not normally distributed are presented as medians with ranges. We used the t test for continuous variables and the Fisher exact tests and chi-square tests for categorical variables. *P* values less than .05 were considered statistically significant. To evaluate factors associated with poor neurologic outcome, multivariate logistic regression analysis was performed. To maximize statistical power and minimize bias that might occur if some missing data were excluded from analyses, we used multiple imputation to impute missing values for levels of serum creatinine and pH.

RESULTS

During the 15-year period, 375 drowning patients were admitted to the hospital. Of these, 213 minors (age <18 years) and 20 incomplete medical records were excluded, leaving 142 patients in the analysis. The demographic characteristics were assessed for the 142 adult drowning patients; 86 (60.6%) were men, and 56 (39.4%) were women. The ages ranged from 18 to 92 years, and the mean age was 50.6 (19.8) years. The median duration of submersion was 6 minutes. The median date and time of hospital arrival were 3.3 hours. Ninety-one cases occurred in the summer or autumn (spring:summer:autumn:winter=25:36:55:32), and most occurred in rivers (sea water:river water:wastewater=19:93:32). The patients were divided into two groups according to the presence of cardiac arrest and then by neurological outcome (**Figure 1**).

Patients with good versus poor neurological outcome

Compared with patients with good neurological outcomes, patients with poor neurological outcomes exhibited significant differences in the incidence of cardiac arrest (*P*<.001), initial heart rate (*P*=.002), lowest body temperature within 96 hours of admission (*P*<.001), initial GCS score (*P*<.001), initial pH (*P*=.006), initial levels of glucose (*P*=.021), serum creatinine (*P*=.015), and lactic acid (*P*=.003), incidence of endotracheal intubation (*P*<.001), incidence of pneumonia (*P*=.003), incidence of hypotension during hospitalization (*P*<.001), usage of vasoactive agents (*P*<.001) and incidence of ICU admission (*P*<.001) (**Table 1**).

Patients without cardiac arrest

Among the 97 patients without cardiac arrest, 90 had good neurological function outcomes, and 7 had poor neurological function outcomes (**Table 2**). Compared patients with good outcomes, patients with poor outcomes exhibited statistically significant differences in the incidence of wastewater drowning (P=.023), initial heart rate (P=.016), highest temperature within 96 h of admission (P=.014), initial lactic acid level (P=.007), incidence of acute respiratory distress syndrome (ARDS) (P=.032), incidence of endotracheal intubation (P=.003), incidence of hypotension during hospitalization (P=.005), usage of vasoactive agents (P<.001) and incidence of ICU admission (P<.023). Seven patients without cardiac arrest had poor neurological outcomes; their median (range) age was 72 (42-90) years (**Table 3**). The body temperatures of five of these patients within 96 hours of admission were over 38°C. One patient with hypotension under vasoactive agents was considered for septic shock. Six patients received endotracheal intubation and mechanical ventilation after admission, and the arterial oxygen saturation of three of these patients was below 90%, even when gas exchange functioned. Five patients received glucocorticoids to reduce pulmonary injury.

Patients with cardiac arrest

Among the 45 patients with cardiac arrest, 28 had good neurological outcomes, and 17 had poor neurological outcomes (**Table 4**). Compared with patients with good neurological outcomes, patients with poor neurological outcomes exhibited statistically significant differences in duration of CPR (P=.015), initial heart rate (P=.043), lowest body temperature within 96 hours of admission (P=.002), initial GCS score (P=.001), initial pH (P=.007), initial levels of glucose (P=.002) and lactic acid (P=.047), incidence of pneumonia (P=.015), incidence of endotracheal intubation (P=.007), incidence of hypotension during hospitalization (P<.001), usage of vasoactive agents (P<.001) and incidence of ICU admission (P<.001). Seventeen patients had poor neurological outcomes. Nine patients were male, and the mean age was 52 years. The median duration of submersion was 12.5 minutes. Nine patients had ROSC after CPR in the field, and 8 patients had ROSC after CPR in the hospital. Sixteen patients were still unconscious after ROSC. Ten patients had hypotension during hospitalization, and three had hypotension under vasoactive agents. Four patients had an arterial oxygen saturation below 95%, even when they received endotracheal intubation and mechanical ventilation after admission. Four patients died during hospitalization (**Table 5**).

Multivariable analysis

Logistic regression analysis was performed to identify factors associated with neurological prognosis. Among all the patients, initial lactic acid level (OR: 1.389, 95%CI: 1.010-1.910, P=.043) was associated with neurological prognosis. For patients without cardiac arrest, the initial lactic acid level (OR: 7.679, 95%CI: 1.233-47.826, P=.029) was associated with neurological prognosis. For patients with cardiac arrest, the incidence of ICU admission (OR: 16.604, 95%CI: 1.151-239.486, P=.039) was associated with neurological prognosis (**Table 6**).

DISCUSSION

According to a report by the World Health Organization, 0.7% of deaths worldwide, or more than half a million deaths a year, are caused by drowning.[2] Drowning is a leading cause of death among young men 5-14 years of age. The limited published evidence on risk factors for drowning among children in China has been collected from several provinces.[9,10] The epidemiological characteristics of adult drowning patients are rarely reported.[11] Studies in other countries have reported roughly the same age and sex in adult drowning patients as we report in our study.[12,13]

The primary goal of treatment is to improve the survival rate and neurological outcome of drowning patients. Relevant studies suggest that the survival rate and neurological outcome of drowning patients may be related to various factors, such as duration underwater, drowning witnessed in the field, initial resuscitation in the field, response of emergency medical services, vital and neurological signs on admission, and comprehensive treatment after admission.[12,14-16] The guidelines for

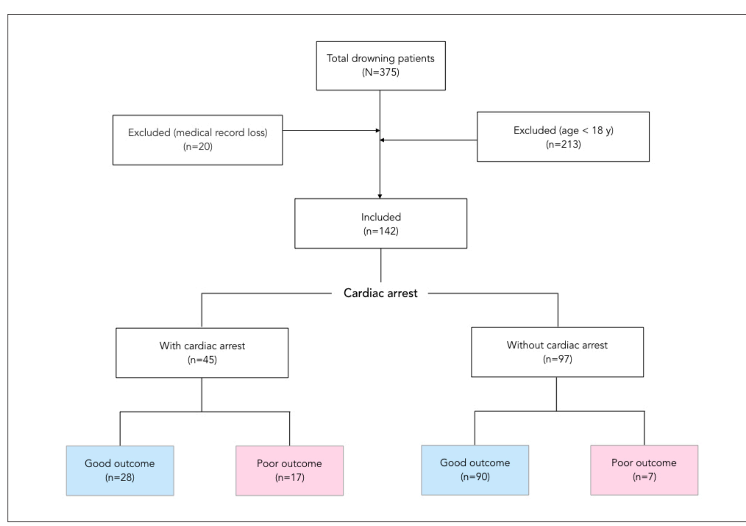

Figure 1. Patient flow diagram.

Table 1 .Neurological outcomes in all drowning patients (n=142).

	Neurological outcome good (n=118)	Neurological outcome poor (n=24)	*P* value
Age (years)	49.8 (19.8)	54.2 (19.6)	.323
Male	71 (60.2)	15 (62.5)	.831
Wastewater drowning	25 (21.2)	7 (29.2)	.394
Duration of drowning (min)	5.5 (0.33, 240)	10 (0.17, 60)	.917
Cardiac arrest	28 (11.0)	17 (70.8)	**<.001**
Coma after drowning	72 (61.0)	18 (75)	.195
Initial blood pressure			
Systolic (mmHg)	128.1 (25.4)	116.8 (31.9)	.058
Diastolic (mmHg)	745 (13.8)	71.3 (19.0)	.343
Initial heart rate (per min)	89.6 (21.5)	105.7 (25.0)	.002
Initial respiratory rate (per min)	22.7 (5.7)	21.7 (9.8)	.493
Initial 96 h highest temperature	37.3 (2.8)	37.6 (1.8)	.693
Initial 96 h lowest temperature	36.0 (0.6)	35.6 (2.0)	**<.001**
GCS on admission	6 (3, 15)	3 (3, 15)	**<.001**
Initial SaO_2 (%)	91.2 (9.0)	87.0 (12.7)	.063
Initial pH	7.4 (0.1)	7.2 (0.2)	**.006**
Initial glucose (mmol/L)	8.5 (3.9)	10.9 (4.4)	**.021**
Initial serum creatinine (mmol/L)	65.1 (6.9, 160)	77 (32, 239.5)	**.015**
Initial lactic acid (mmol/L)	3.1 (0.7, 9)	10.5 (1.6, 12)	**.003**
Pneumonia	111 (94.1)	18 (75)	**.003**
ARDS	20 (16.9)	6 (25)	.352
Endotracheal intubation	37 (31.4)	22 (91.7)	**<.001**
Duration of intubation (days and range)	3 (1, 9)	2.5 (0.5, 48)	.353
Hypotension	1 (0.8)	12 (50)	**<.001**
Vasoactive agents	5 (4.2)	18 (75)	**<.001**
ICU admission	24 (20.3)	19 (79.25)	**<.001**

Data are expressed as mean (standard deviation) or number (%) unless noted otherwise. [a]SaO_2: arterial oxygen saturation, sCr: serum creatinine, LA: lactic acid, ARDS: acute respiratory distress syndrome.

CPR suggest that submersion duration is associated with patient survival and neurological outcomes.[17]

Another study showed that all 56 patients with submersion durations less than 10 minutes survived, while none of the 7 patients with submersion durations more than 10 minutes survived.[18] In this study, the median submersion duration was 10 minutes in the group with poor neurological outcomes and 5.5 minutes in the group with good neurological outcomes, which was roughly consistent with other studies.

Having witnesses in the field means earlier first aid and resuscitation. Several studies found having witnesses in the field was related to good neurological outcomes. Initial resuscitation includes establishment of an airway, artificial breathing (mouth-to-mouth breathing) and chest compression for circulation. In contrast to other causes of cardiac arrest, injury related to cardiac arrest by drowning is mainly due to insufficient oxygen. Tobin et al found that bystander CPR after drowning could improve the survival rate and neurological function prognosis of patients.[19] In our study, 28 patients with good neurological outcomes underwent CPR in the field, while 17 patients with poor neurological outcomes underwent CPR in the field, showing a statistically significant difference. In patients with cardiac arrest, the median duration of CPR was 10 minutes in those with a good neurological prognosis, and the ROSC rate in the field was 53.6%, while the median duration of CPR was 25 minutes in patients with a poor neurological prognosis, and the ROSC rate in the field was 29.4%. For drowning patients with cardiac arrest, CPR in the field was not a factor affecting the prognosis, but the duration of CPR affected neurological prognosis. The duration of CPR suggested that the longer the duration of CPR, the more severe the illness and injury and the more likely it was that the patient would exhibit a poor neurological function outcome.

Grmec et al found that drowning patients had higher survival rates and were more likely to receive vasoactive agents than those with other causes of cardiac arrest.[6] In our study, a total of 45 patients had cardiac arrest caused by drowning, 4 patients died before discharge, and 17 patients were discharged with poor outcomes of neurological function, which was significantly higher than the survival rate of cardiac arrest caused by other causes.

Once the patient has asphyxia or dyspnea, oxygenation should be improved. Popović et al study highlighted the impact of early endotracheal intubation on patient outcomes.[20] In another study, mechanical ventilation was associated with neurological outcomes in patients without cardiac arrest.[21] In our study, a total of 59 patients received endotracheal intubation and mechanical ventilation. Patients who received endotracheal intubation and mechanical ventilation exhibited significantly improved oxygen supply and respiration.

The neurological examination of patients on admission is of great value to the prognosis of neurological function. The GCS score plays an important role in observing the trend of neurological function and judging the prognosis of patients.[7] In another study, the accuracy of the GCS score could better predict neurological function in patients with cardiac arrest.[22] Our study found that the GCS score on admission was associated with the prognosis of neurological function and was lower in patients with poor neurological outcomes than in patients with good neurological outcomes.

The body temperature within 96 hours of admission affects the prognosis of neurological function. Although hypothermia therapy plays a significant role in the protection of neurological function in patients after cardiac arrest, maintaining appropriate hypothermia, such as 32°C to 34°C for 24 hours, has a neuroprotective effect.[23,24] However, hypothermia on admission sometimes suggests that the patient has been immersed in water for too long and may have a poor neurological outcome. Therefore, unlike moderate hypothermia-induced therapy, hypothermia on admission generally indicates a poor neurological outcome. In this study, compared with patients with good outcomes, drowning patients with cardiac arrest and those with lower average temperatures on admission (36.7°C, 34.9°C) had poor outcomes. Nine of 19 cardiac arrest patients with poor outcomes had an average temperature of less than 36°C. Among the 9 patients, 7 did not have ROSC on admission, which may be because patients who need ROSC after appropriate hypothermia therapy can play a role in neurological protection.

A high temperature within 96 hours of admission also affects the prognosis. The cause of a patient's fever may be infectious or noninfectious; for drowning patients, pneumonia is one of the infectious causes of fever. After drowning, pneumonia is the most common complication, and antibiotic therapy is required during hospitalization. Broad-spectrum antibiotics are used first, and definitive antibiotic therapy is adjusted according to the results of infection indicators and bacterial culture. In one study, 43.1% of the patients had pulmonary edema after drowning, and 14.7% had pneumonia.[21] The occurrence of pneumonia was related to the body of water where drowning occurs, and the development of pneumonia is faster after sewage inhalation.[21] In this study, 129 patients were diagnosed with pneumonia, 19 patients were diagnosed with pul-

Table 2. Neurological outcomes of drowning patients without cardiac arrest (n=97).

	Neurological outcome good (n=90)	Neurological outcome poor (n=7)	*P* value
Age (year)	51.8 (19.8)	64.0 (18.7)	.119
Male	53 (58.9)	6 (85.7)	.318
Wastewater drowning	19 (21.1)	5 (71.4)	**.023**
Duration of drowning (min)	5 (0.33, 240)	5 (1, 17)	.06
Coma after drowning	44 (48.9)	2 (28.6)	.52
Initial BP			
Systolic pressure (mmHg)	129.2 (25.6)	125.1 (33.8)	.698
Diastolic pressure (mmHg)	74.8 (12.6)	67.7 (16.6)	.192
Initial heart rate (per min)	90.1 (20.6)	110.6 (29.7)	**.016**
Initial respiratory rate (per min)	23.0 (5.9)	28.1 (13.0)	.114
Initial 96 h highest temperature	37.2 (3.2)	38.8 (1.1)	**.014**
Initial 96 h lowest temperature	36.6 (0.7)	37.2 (0.6)	.2
Initial SaO_2 (%)	91.5 (8.3)	92.0 (7.8)	.893
Initial pH	7.4 (0.1)	7.3 (1.4)	.547
Initial glucose (mmol/L)	8.6 (3.9)	7.0 (1.4)	.303
Initial serum creatinine (mmol/L)	68.8 (25.5)	83.7 (43.5)	.421
Initial lactic acid (mmol/L)	3.1 (0.7, 8.3)	6 (5.9, 12)	**.007**
Pneumonia	84 (93.3)	7 (100)	.999
ARDS	23 (25.6)	5 (71.4)	**.032**
Endotracheal intubation	23 (25.6)	6 (85.7)	**.003**
Duration of intubation (days and range)	3 (1, 9)	1 (0.5, 5)	**.021**
Hypotension	0	2 (28.6)	**.005**
Vasoactive agents	4 (4.4)	5 (71.4)	**<.001**
ICU admission	19 (21.1)	5 (71.4)	**.023**

Data are expressed as mean (standard deviation) or number (%) unless noted otherwise. SaO_2: arterial oxygen saturation, ARDS: acute respiratory distress syndrome.

Table 3. Drowning patients who did not suffer cardiac arrest and were discharged with poor neurological outcomes (n=7).

Sex	Age (y)	Duration of drowning (min)	Mental status	Initial GCS	Lowest temperature (°C)	Highest temperature (°C)	Bacterial culture	Heart rate (/min)	Blood pressure (mmHg)	Respiratory rate (/min)	SaO_2 (%)
M	74	Unknown	Coma	3	36.8	39.3	+	108	118/60	21	96.3
M	77	Unknown	Normal	10	37.5	39	+	141	60/36	30	86
M	90	0.17	Coma	Unknown	36.5	38.6	+	112	170/81	34	96.8
M	72	Unknown	Normal	Unknown	36.6	38.8	-	77	131/66	124	96.7
F	42	5	Normal	Unknown	36.9	37.3	-	84	131/74	23	89.9
M	46	1	Normal	Unknown	37.7	37.7	-	94	146/87	12	100
M	47	Unknown	Normal	Unknown	38.2	40.8	-	158	120/70	53	78

GCS: Glasgow coma scale. SaO_2: arterial oxygen saturation.

Table 3 (cont.) Drowning patients who did not suffer cardiac arrest and were discharged with poor neurological outcomes (n=7).

Sex	Age (y)	Pupil size(mm)	Pupil light reflex	Hypotension ≥2	Pneumonia	Pulmonary edema	Intubation	Glucocorticoid	Hospital stay (d)	GCS at discharge
M	74	3/3	Unknown	-	+	-	-	-	8	Unknown
M	77	2/2	Unknown	-	+	-	+	+	12	4
M	90	2.5/2.5	Unknown	-	-	-	+	+	6	3
M	72	2/2	+/+	-	+	+	+	+	32	6
F	42	3/3	+/+	+	+	-	+	+	2	Dead
M	46	Unknown	+/+	-	+	-	+	-	1	3
M	47	Unknown	-/-	+	+	-	+	+	3	3

Table 4. Neurological outcomes in patients with cardiac arrest (n=45).

	Neurological outcome good (n=28)	Neurological outcome poor (n=17)	*P* value
Age (year)	43.4 (18.7)	50.2 (19.0)	.25
Sex			
Male	18 (64.3)	9 (52.9)	.337
Duration of drowning (min)	6 (1, 60)	10 (2, 60)	.256
Cardiac arrest			
CPR	24 (85.7)	13 (76.5)	.701
Duration of CPR (min)	10 (2, 30)	25 (3, 60)	**.015**
ROSC in the field	15 (53.6)	5 (29.4)	.114
Coma after drowning	28 (100)	16 (94.1)	.378
Initial blood pressure			
Systolic pressure (mmHg)	124.8 (24.8)	113.3 (31.5)	.18
Diastolic pressure (mmHg)	73.3 (14.4)	72.8 (20.2)	.924
Initial heart rate (per min)	88.2 (24.5)	103.6 (24.5)	**.043**
Initial respiratory rate (per min)	21. 8 (4.6)	19.0 (6.9)	.116
Initial 96 h lowest temperature	36.7 (0.8)	34.9 (2.0)	**.002**
GCS on admission	10.9 (4.4)	4.4 (3.4)	**.001**
Initial SaO_2 (%)	90.4 (11.0)	84.8 (14.0)	.161
Initial pH	7.3 (0.1)	7.1 (0.3)	**.007**
Initial glucose (mmol/L)	8.2 (3.8)	12.6 (4.2)	**.002**
Initial serum creatinine (mmol/L)	70 (33.2, 145)	84 (32, 239.5)	.098
Initial lactic acid (mmol/L)	3 (1.3, 9)	12 (1.6, 12)	**.047**
Pneumonia	27 (96.4)	11 (64.7)	**.015**
ARDS	9 (32.1)	8 (47.1)	.317
Endotracheal intubation	14 (50)	16 (94.1)	**.007**
Duration of intubation (day)	3.5 (1, 7)	3 (1, 48)	.757
Hypotension	1 (3.6)	10 (58.8)	**<.001**
Vasoactive agents	1 (3.6)	13 (76.5)	**<.001**
ICU admission	5 (17.9)	14 (82.4)	**<.001**

Data are expressed as mean (standard deviation) or number (%).

SaO_2: arterial oxygen saturation, ROSC: restoration of spontaneous circulation, ARDS: acute respiratory distress syndrome.

Table 5. Drowning patients with cardiac arrest who were discharged with poor neurological outcomes (n=17).

Sex	Age (y)	Duration of drowning (min)	CPR time (min)	ROSC In the field	Hospitalization CPR	ROSC in the hospital	Mental status	Initial GCS	Lowest temperature (°C)	Heart rate (per min)	Blood pressure (mmHg)
M	82	2	10	+	-	-	Coma	Unknown	36.2	88	123/76
M	51	2	Unknown	+	-	-	Coma	4	36.8	78	142/95
M	36	20	50	-	+	-	Coma	3	35.3	110	80/60[a]
M	50	2	20	-	+	+	Coma	3	34.2	112	132/86
M	40	15	30	-	+	+	Coma	3	31.9	91	85/46[a]
F	76	60	60	-	+	+	Coma	3	32.1	101	74/58[a]
M	51	50	30	-	+	+	Coma	3	31.2	86	137/90[a]
F	56	10	Unknown	+	+	+	Coma	15	36.4	91	120/64
M	30	10	3	+	+	-	Coma	4	37.6	150	109/74
F	50	Unknown	Unknown	+	-	+	Coma	4	37	129	145/89
F	20	Unknown	Unknown	-	+	-	Coma	3	33.8	119	65/36[a]
M	57	Unknown	Unknown	+	-	-	Normal	3	36.4	137	137/93
M	39	10	Unknown	+	-	-	Coma	5	36.6	110	111/86
F	27	Unknown	Unknown	+	-	+	Coma	3	35	102	127/100
F	34	5	20	+	-	-	Coma	3	32.4	119	51/37[a]
F	73	10	Unknown	-	+	+	Coma	3	35	84	126/65
F	81	Unknown	Unknown	-	+	-	Coma	4	36.2	55	162/83

Table 5 (cont.). Drowning patients with cardiac arrest who were discharged with poor neurological outcomes (n=17).

Sex	Age (y)	Respiratory rate (/min)	SaO_2 (%)	Pupil size (mm)	Pupil light reflex	Hypotension ≥2 times	Complicating illness	Intubation	Glucocorticoid	Hospital stay (d)	GCS at discharge
M	82	24	88[b]	2/2	+/+	-	ARDS,PI, RF	+	+	6	Unknown
M	51	12	94.6	2.5/3.5	+/+	-	HE	+	+	4	4
M	36	24	73[b]	4/4	-/-	+	ARDS RF	+	+	1	Dead
M	50	29	97[b]	3/3	-/-	-	-	+	-	40	6
M	40	20	81[b]	4/4	-/-	+	-	+	+	1	Dead
F	76	18	84.8[b]	6/6	-/-	+	HE, MODS	+	+	3	3
M	51	23	98[b]	4/4	-/-	+	HE	+	+	56	3
F	56	27	96.8	2/2	+/+	+	RF, PI	+	+	15	Unknown
M	30	15	55[b]	3.5/3.5	+/+	-	PI	+	+	20	Unknown
F	50	19	88	5/5	-/-	+	ARDS, MODS	+	+	2	Unknown
F	20	15	Unknown	Unknown	-/-	+	PI	+	+	2	Dead
M	57	15	64[b]	5/4	-/-	+	-	+	-	3	Unknown
M	39	20	72	3/3	+/+	-	PI	+	+	20	Unknown
F	27	0	95	5/5	-/-	+	PI	+	+	2	Dead
F	34	24	84	5/5	-/-	+	-	+	+	1	Unknown
F	73	14	98	4/4	-/-	-	PI	+	+	3	4
F	81	24	99	3.5/2	-/-	-	-	-	+	10	5

ARDS: Acute Respiratory Distress Syndrome, PI: pulmonary infections, RF: respiratory failure, HE: hypoxic encephalopathy, MODS: multiple organ dysfunction syndrome, [a]Maintain blood pressure by vasoactive agents, [b]Maintain arterial oxygen saturation by mask or mechanical ventilation.

Table 6. Factors associated with neurologic outcome in drowning patients (n=142).

	OR	95% CI	*P* value
Initial lactic acid all patients (n=142)	1.389	1.010-1.910	.043
Initial lactic acid without cardiac arrest (n=97)	7.679	1.233-47.826	.029
ICU admission with cardiac arrest (n=45)	16.604	1.151-239.486	.039

Dependent variable poor or good neurologic outcome. Model summary measures: deviance 13.162 Cox Snell .321, Nagelkerke .785, Overall χ^2 36.820, df 6, *P*<.001.

monary edema, and 139 patients were treated with prophylactic or therapeutic antibiotics. The main concerns focus on neurological injury to the brain and other multisystem impairments when hyperpyrexia occurs.[25] Meanwhile, wastewater drowning and the incidence of pneumonia had a statistically significant effect on neurological outcome. Once the results of pathogen testing and sensitivity testing are available, therapy should be adjusted accordingly.

Lactic acid plays an important role in the severity and prognosis assessment of shock patients.[26,27] The detection of lactic acid level is objective. Shapiro et al showed that blood lactic acid level could be a predictor of mortality in patients with emergency infections. Compared with the blood lactic acid level, dynamic monitoring of blood lactic acid was more significant and supported lactic acid as a promising risk-stratification tool.[28] In our study, initial lactic acid level was associated with the prognosis of neurological function. Patients with poor neurological outcomes had a higher median lactate level than patients with good neurological outcomes.

This study has several limitations. First, the number of drowning patients was only 142, and some prognostic factors were not included. Second, we judged neurological outcome by CPC score, without long-term neurological outcome. In conclusion, for drowning patients with cardiac arrest, ICU admission was associated with the prognosis of neurological function. Among the patients without cardiac arrest, the initial lactic acid level was associated with the prognosis of neurological function.

Author contributions

ZPL, PSZ, HQX and CBY designed the study and drafted the manuscript; ZPL and PSZ helped interpret the results and write some discussion; BCL, CBY and HQX helped in the statistical analysis and result interpretation; ZLZ and JCS prepared the figures and interpret the results. ZPL and PSZ are identified as the guarantors of the paper, taking responsibility for the integrity of the work as a whole, from inception to published article.

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Supplementary Table. Guidance for neurological outcomes in adult drowning in patients.

Item description	Explanation	Other
1. Report the background of drowning	Drowning is the third leading cause of unintentional death worldwide and approximately 60,000 people died from unintentional drowning in China.	
2. Report the difference of drowning patients with CPR and without CPR	CPR accounts for 30% drowning patients and the survival rate was difference with other cardiac arrest.	
3. Report the patients	We collected demographic and clinical data on drowning patients between September 2006 and January 2020.	
4. Report the data we collected	All data were collected from the medical record system and analyzed from the day of admission to the day of discharge.	
5. Report the statistical method	All data were recorded and analyzed using SPSS 21. We used t-tests for continuous variables and Fisher's exact tests and chi-square tests for categorical variables.	
6. Report the result of general clinical data	The demographic characteristics were assessed for the 142 adult drowning patients.	
7. Report the result of neurological outcome	The factors influencing neurological outcome of 142 adult drowning patients.	
8. Report the result of drowning patients without cardiac arrest	The difference between good and poor neurological outcome of drowning patients without cardiac arrest.	
9. Report the result of drowning patients with cardiac arrest	The difference between good and poor neurological outcome of drowning patients with cardiac arrest.	
10. Report the result of logistic regression	Logistic regression analysis was performed to identify predictive factors of neurological prognosis.	
11. Report on treatment strategies for drowning patients	The primary goal of treatment is to improve the survival rate and neurological outcome of drowning patients.	
12. Report submersion duration was associated with patients' survival	The American Heart Association (AHA) 2020 guidelines for cardiopulmonary resuscitation suggest that submersion duration is associated with patient survival and neurological outcomes. This study was roughly consistent with other studies.	
13. Report Initial resuscitation was associated with patients' survival	Initial resuscitation includes establishment of an airway, artificial breathing (mouth-to-mouth breathing) and chest compression for circulation.	
14. Report oxygenation was associated with patients' survival		
15. Report neurological examination was associated with patients' survival	The GCS score, alert-verbal-painful-unresponsive (AVPU) score and Aristotle Basic Complexity (ABC) score are important factors in evaluating the neurological function of patients at admission.	
16. Report temperature within 96 h of admission was associated with patients' survival	The lowest body temperature (36°C) within 96 h of admission affects the prognosis of neurological function. The highest temperature (38°C) within 96 h of admission was a predictive factor of the prognosis of neurological function.	
17. Report Lactic acid was associated with patients' survival	Lactic acid is a byproduct of anaerobic metabolism and a marker of tissue hypoxia or shock. Lactic acid plays an important role in the severity and prognosis assessment of shock patients.	