Analysis of the characteristics and management of critical values in a newborn tertiary center in China

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Background: **Critical value reporting has been widely adopted by hospitals throughout the world, but there were few reports about neonatal critical values. This study aimed to analyze characteristics of the neonatal critical values considered at our center and to provide information on improving neonatal intensive care.**

Methods: **A retrospective study of critical values at a newborn tertiary center in China was conducted to assess neonatal critical values according to test, distribution, reporting time, patient outcome and the impact to the therapy.**

Results: **In total, 926 critical values were recorded. Overall, 66.52% (616/926) of the items were reported within 24 hours of admission, 50.28% (465/926) during duty times and 54.75% (507/926) in the neonatal intensive care unit (NICU). The routine coagulation test was the most frequent source of critical values. Electrocardiography, blood gas analysis and therapeutic drug monitoring of drug levels were associated with the highest rates of treatment intervention (100%); routine coagulation tests were the lowest (23.14%). Sample quality was the main cause of false-positive critical values.**

Conclusions: **The incidence of neonatal critical values peaked during the first 24 hours post-admission and during duty periods. Each newborn center needs to enact rapid treatment guidelines to address common critical values in order to facilitate clinical interventions. Periodically reviewing critical values could help to optimize clinical practices.**

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Introduction

Critical value reporting was introduced by Lundberg in 1972;[1] he defined critical values as "pathophysiologic derangements of such variance with normal as to be life threatening if therapy is not instituted immediately." During the 40 years since Lundberg's observations, the critical value reporting system has been widely adopted by hospitals throughout the world. Even The Joint Commission (TJC) and the College of American Pathologists have included this system in their requirements for accreditation.[2,3] The Chinese Hospital Association also imposed requirements for the identification, handling and documentation of critical laboratory values from 2007 to 2011.[2] In general, laboratories should consider hospital size, diagnosis, treatment and other relevant parameters to establish a critical value list with reference ranges.[4] Laboratories often establish critical values based on the current understanding of pathophysiology, published literature, discussions with clinical staff and the particular needs of the clinic.[2] Furthermore, the neonatal period is characterized by extreme changes in certain parameters; these changes enable adaptation to the extra-uterine environment, thus creating the need for a special critical value list.[5]

Reporting inappropriate critical values can lead to information overload for pediatricians and can waste clinical resources. Currently, there are no unified standards for critical values, and these criteria are amended locally according to laboratory practices and equipment/reagents. Thus, laboratory and hospital accreditation organizations urgently need studies to aid in the development of neonatal criteria for accreditation. In this case, we undertook a project to analyze the characteristics and management of neonatal critical values in a newborn tertiary center in China. The aims

of this study were to (a) explore the characteristics and management of neonatal critical values at our center and (b) provide useful information for hospitals with regard to improving neonatal intensive care.

Methods

Setting

The Department of Neonatology, Children's Hospital of Chongqing Medical University, Chongqing, China, is a national clinical specialty department that is divided into three sub-wards: the neonatal intensive care unit (NICU, for critically ill newborns only), the premature infant ward (for premature only) and the term infant ward (for term only). There are currently 215 beds: 40 for the NICU and 175 for intermediate care (which includes the premature infant ward and the term infant ward). Critical values reported from July 1 to December 31, 2013, were examined. The critical value lists, including the test items and ranges from 2012, are shown in Tables 1&2. The lists are typical of tertiary children's hospitals in China, which are based on reports from the College of American Pathologists[3,6,7] and the patient safety requirements of the Chinese Hospital Association[2] in consultation with relevant clinical experts, and these lists are approved by the medical quality committee of the hospital.

Routine lab schedules and interventions for critical values

All the infants in our center were transferred from local hospitals; all of these infants were in a relatively more severe condition and thus required monitoring of more critical values than those in other centers. It is routine procedure in our unit to analyze glucose, electrolytes, blood cell counts, blood urea nitrogen, creatinine, and coagulation [prothrombin time (PT), activated partial thromboplastin time (APTT), fibrinogen (Fib)] in all infants immediately after admission, and the inclusion of other tests depends on the clinical symptoms. The infants in the NICU will receive the glucose test every day and the infants with mechanical ventilation will receive the blood gas analysis at least once a day.

Critical callback procedures

Tables 1&2 show the critical callback list that has been used by our hospital since June 2012. When a critical value is detected by a laboratory technician, the specimen information (e.g., specimen quality, name, department and diagnosis) should be checked immediately, and the test should be repeated. Once the critical result has been validated, the laboratory information system sends a short message and a screen reminder to the pediatricians on the floor where the patient is located. In addition, the technician must call the physician to notify him/her of the critical values. All phone contact details (e.g., the name of the patient, critical value result, time and contact staff) are recorded in a critical value register book. The pediatrician should then take corrective action within 15 min. Most of the interventions in response to critical values were symptomatic treatments.

Ethics statement

This study was approved by the Children's Hospital of Chongqing Medical University, Chongqing, China, and was performed in accordance with the Declaration of Helsinki. The institutional review board waived the need for written informed consent from the participants.

Table 1. Critical value list for laboratories (neonatal)

Analytes	Critical value range	
	Low threshold	High threshold
Potassium, mmol/L	<2.5	>6.5
Sodium, mmol/L	<120	>160
Magnesium, mmol/L	-	>4
Glucose, mmol/L	≤2.6	≥30† (16.7*)
Blood urea nitrogen, mmol/L	-	>20
Creatinine, mmol/L	-	>500†
Arterial pH	≤7.2	≥7.6
PCO_2, kPa	<2.66	>7.98
PO_2, kPa	<5.98	-
Hemoglobin, g/L	<60‡ (90*)	-
White blood cell count, $\times 10^9$/L	-	>50
Platelet count, $\times 10^9$/L	<30‡ (50*)	>1000
Fibrinogen, g/L	≤0.5	-
Prothrombin time, s	-	≥180†
Partial thromboplastin time, s	-	≥240†
Blood culture	Positive growth	-

*: New thresholds for critical values being planned in our center; †: The thresholds may be too high for other centers; ‡: The thresholds may be too low for other centers. "-": not applicable.

Table 2. Critical value list for imaging departments

Sub-departments	Critical value list
Radiology department	Cerebral hernia; Large area of cerebral infarction; Severe intracranial hemorrhage; Foreign body in trachea; Pneumothorax; Mediastinal emphysema; Pneumoperitoneum or NEC; Ileus; Visceral rupture; HMD; Other life-threatening image changes.
Ultrasound department	Intracerebral hemorrhage; Visceral rupture; Massive pericardial effusion or pericardial tamponade; Pneumoperitoneum; Pneumothorax; Massive pleural effusion with pulmonary atelectasis.

NEC: neonatal necrotizing enterocolitis; HMD: hyaline membrane disease.

Data sources

All data were retrospectively analyzed from records collected between July 1 and December 31 of 2013. The critical laboratory values and imaging results from the Radiology and Ultrasound departments (as well as other departments) were obtained from the critical value register book, and electronic records were obtained from the laboratory information system. The data included the unique patient identification number, patient name, tests, diagnosis, analyte(s), result, department, report time, patient outcome and treatment intervention. We defined the outcome that the patients were cured and discharged without any adverse effects as "improved". If we needn't modify the treatment after a critical value was reported, we regarded it as "negative impact" on treatment; otherwise, it was regarded as "positive impact". In addition, all of the repeated critical values except coagulation tests were regarded as "valuable reports".

Statistical analyses

All statistical analyses were performed using SPSS 19.0 for Windows (IBM SPSS Statistics 19). Frequencies, medians and percentages were used to describe the descriptive statistics. Patient outcome was determined based on the discharge records, and this variable was categorized as improved, not improved or dead. The gestational age and birth weight are presented as the mean±SD.

Results

Patient demographics

A total of 926 critical values from 631 admissions (380 males and 251 females) were recorded. The overall mean gestational age and birth weight of the neonates were 35.48±3.85 weeks and 2444.8±802.8 g, respectively. There were 100 infants at a gestational age <32 weeks, 220 infants at 32-36 weeks and 311 infants at >37 weeks. As shown in Table 3, routine coagulation

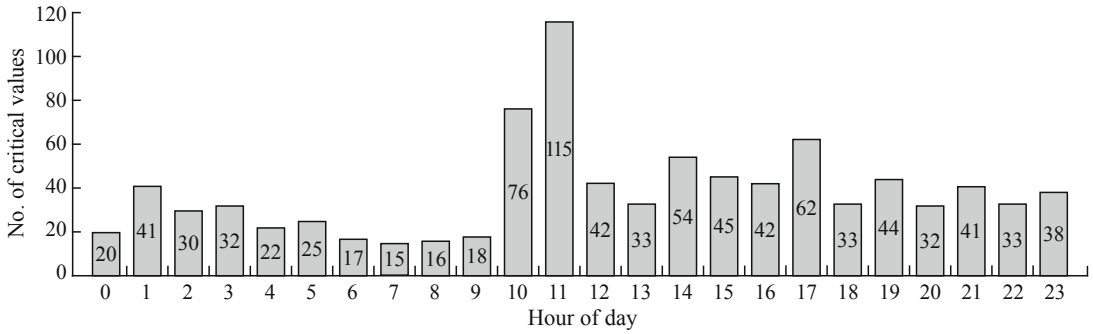

Fig. Critical value *vs.* time of day. Distribution of critical value calls *vs.* time (24-h clock) for newborns. Critical values increased after 10 a.m. and continued toward late PM, increasing the load on the fewer residents on call.

Table 3. The distribution of critical/vital values by test

Test	Total results	Critical results (% of total test*)	Percentage of all critical results, %	Positive impact on treatment rate (%)†	Treatment before report (% of total test)‡	Total patients§	No. of critical test results from each ward		
							NICU	Premature infant ward	Term infant ward
Routine coagulation tests‖	4186	242 (5.8)	26.1	23.1	186 (76.9)	224	87	55	100
Potassium	4760	98 (2.1)	10.6	67.3	0	81	42	16	40
Sodium	4760	4 (0.1)	0.4	100	0	4	4	0	0
Blood culture	651	96 (14.7)¶	10.4	42.7	55 (57.3)	80	49	10	37
Imaging tests	2583	132 (5.1)	14.3	72.7	36 (27.3)	121	102	5	25
Glucose	3588	210 (5.9)	22.7	97.6	5 (2.4)	153	108	57	45
Blood cell counts**	8810	56 (0.6)	6.0	82.1	10 (17.9)	40	40	6	10
Blood urea nitrogen	4760	28 (0.6)	3.0	71.4	8 (28.6)	20	21	2	5
Electrocardiography	188	4 (2.1)	0.4	100	0	4	4	0	0
TDM drug levels	49	1 (2.0)	0.1	100	0	1	0	0	1
Blood gas analysis	894	55 (6.2)	5.9	100	0	52	53	1	1
Total	35229	926 (2.6)	100.0	64.1	300 (32.4)	780†	510	152	264

*: Total is not 100.0% because of rounding; †: If the treatment or management required making an adjustment when a certain critical value was obtained, we regarded this critical value as having a "positive impact" on treatment and management; otherwise, it was regarded as having a "negative impact"; ‡: "Treatment before report" represents the treatment had already been addressed before the critical value call; §: For practical reasons, each critical result here was calculated as being associated with one patient. For example, if a patient presented critical values for 2 analytes, the values were recorded as corresponding to 2 patients. Therefore, the total number of patients (780) in the table was higher than the actual number of patients (631); ‖: Routine coagulation tests include prothrombin time, activated partial thromboplastin time, fibrinogen; ¶:Some samples may be reported more than once as there were ≥2 kinds of bacteria detected; **: Blood cell counts: hemoglobin, white blood cell count and platelet count. TDM: therapeutic drug monitoring.

tests, which included prothrombin time, activated partial thromboplastin time and fibrinogen, were the most common critical values (242 cases), followed by glucose tests (210 cases), imaging tests (132 cases), electrolyte tests (102 cases) and blood culture tests (96 cases).

Analysis of the timing of neonatal critical values

The analysis of "call volumes *vs.* time" (Fig.) revealed that the neonatal critical value call volumes were unevenly distributed throughout the 24-hour day, ranging from 15 calls from 7:00 to 7:59 a.m. to 115 calls from 11:00 to 11:59 a.m. Overall, the neonatal critical value calls occurred primarily from 10:00 a.m. to 5:59 p.m., with decreased rates during the late night and early morning. It was unexpected that approximately 53.8% (498/926) of the critical values were reported during the night shift (6:00 p.m.-7:59 a.m. the next day) and the lunch break (12:00-1:59 p.m.) when only one or two pediatricians were on duty.

Critical value turnaround time

The "in-laboratory" turnaround time for each critical value was determined to assess the timeliness of critical value reporting.[6] For the 926 critical values, the mean time from entering the value in the critical callback queue to the time when the critical value information was conveyed to the ordering clinician or newborn center was 12 minutes, and the median time was 8 minutes (data not shown). Delays in critical value reporting correlated with unqualified specimens (a new sample was required) and with tests ordered on requisitions lacking the name of the ordering location. After receiving the reports, the clinicians were able to intervene within 15 minutes with the help of our centers' policy on how to handle the common critical values urgently.

Distribution of neonatal critical values after admission

There were 926 critical values recorded during the study period. Neonatal critical value reports were most frequently made in the NICU, accounting for 54.8% (507/926) of the total and 2.1 critical values per month per bed, while 16.6% (154/926) of the total and 0.6 critical values per month per bed occurred in the premature infant ward, and 28.6% (265/926) of the total and 0.3 critical values per month per bed originated from the term infant ward. Premature infants were at a higher risk of having a critical value than term infants.

Over all, 66.5% (616/926) of the critical values occurred within 24 hours after admission, and 74.7% (692/926) of the values occurred within 48 hours. Routine coagulation tests and blood glucose tests were the most common sources of critical values during the first 48 hours after admission.

Impact on management

Critical values usually indicate a life-threatening state unless corrective action is taken. In general, if a pediatrician has already initiated appropriate treatment before a critical value is found, no other treatment interventions are needed. For example, we perform certain routine interventions (i.e., hemostatic treatment) for high-risk neonates before obtaining test results. In this situation, we regard a critical value as having a "negative impact" on treatment or management; otherwise, it is regarded as having a "positive impact". For example, our center would repeat the blood gas analysis at least once a day for neonates receiving mechanical ventilation. If the results were critical, we should modify the mechanical ventilation parameters and treatment plan within 15 minutes once the blood gas analysis critical values are received. In this situation, we regard it as "positive impact". In summary, blood gas analysis, electrocardiography and therapeutic drug monitoring (TDM) of drug levels were associated with the highest rates of treatment intervention following the detection of a critical value (100%), whereas routine coagulation tests were associated with the lowest rate of intervention (23.1%), followed by blood culture (42.7%). In addition, coagulation tests and blood culture tests had the highest rates of treatment that had already been addressed before the critical value call (Table 3).

Analysis of critical values of routine coagulation tests and serum potassium

In this survey, 242 critical values were associated with routine coagulation tests. Of these, 87 critical values were recorded in the NICU, 55 in the premature infant ward and 100 in the term infant ward. There were 18 cases of repeat critical values for coagulation tests in the same patient; the time interval for each repeat critical value ranged from 6 to 23 hours, with a median of 12 hours. As the intervals of repeated critical values were short, medical staffs were clear about the patient's condition and they had modified therapy when they received the former reports. It's very important to notice that the threshold of coagulation tests in our center was the maximum range of our instrument, so these repeated values were always improved or the same as the initial critical value. In this condition, all the 18 cases of repeated coagulation tests critical values had a negative impact on treatment. Approximately 79.3% (192/242) of the routine coagulation test critical values were reported within 24 hours of admission.

The serum potassium test yielded 98 critical values and 38 specimens of which were hemolysis. Overall, only 6 of the hemolyzed specimens remained at a critical level after the lab test was repeated. The

numbers of critical values recorded in the NICU, premature infant ward and term infant ward were 42, 16 and 40, respectively (Table 3).

Outcomes

According to our experience, it would save 0.5-6 hours (including in-laboratory turnaround time, time of specimen collection, time to intervention when received the critical value and so on) for each positive impact critical value with the help of critical value system which could improve neonatal intensive care (data not shown). In total, 73.2% (462/631) of the newborns who presented with at least one critical value were cured and discharged without any adverse effects. 10.46% (66/631) of these infants were transferred to another hospital due to economic factors when their conditions improved (in non-life-threatening situations), and only 1 newborn died of a serious infection and congenital disease in the hospital. However, due to either socio-economic factors or parental concern over possible severe sequelae, the parents of the remaining 16.3% (103/631) infants refused to approve further treatment, and these infants were in critical condition when they were discharged.

Discussion

In the present study, we explored a novel perspective on neonatal critical values in a newborn tertiary center in China. Here, we provide details on patient demographics, volume, report time, scope and impact on the treatment and management associated with these critical values. As a tertiary newborn center, many infants are transferred here from local hospitals, so we have a relatively high percentage and number of severe and emergency infants and thus more critical values.

In fact, some of our critical value items were actually vital values by definition rather than critical values.[8] According to Lundberg,[8] a vital value is as important as a critical value, and labs should design and implement systems that parallel the critical value system. By applying this logic to other settings, we have adopted the use of vital values for positive electrocardiography, blood culture and imaging tests in our reporting system, and reporting these values could contribute to improvements in newborn care.

As is the case in many other newborn units, most of the tests were performed during the first 24 hours after admission, and an increase in the number of samples was associated with a greater number of abnormal results, perhaps because most of the tests were performed in the first 24 hours. Furthermore, it was unexpected that approximately 53.8% (498/926) of the observed critical values were reported during the night shift and lunch break, during which only 2-3 doctors and a few nurses were present. As these staff members may face an overload of critical values,[9] clinical departments should develop emergency response plans for addressing common critical values to save time and improve patient safety.[10,11] As all the infants in our unit were transferred from other hospitals, the incidence of hypoglycemia critical values was high, and these critical values always happened within 6 hours or within 24-48 hours after admission. Therefore, we suggest that: (1) all babies have their glucose levels tested during transfer, at the time of hospital admission and the next day after admission; (2) these babies with hypoglycemia need a source of glucose during transfer; (3) infants in the NICU should have glucose tests repeated every day.

Indeed, our practices have changed since this survey. To avoid the reporting of too many critical values during the night shift and lunch break, we now order tests between 8:30 and 9:30 a.m.; this is approximately 1 hour earlier than we previously ordered tests. This not only allows more tests to be conducted during the off-peak hours of the clinical laboratory, which helps decrease the turnaround time for each sample, but also reduces the number of critical values that are reported during the night shift and lunch break. Laboratories should periodically review and update critical value lists[12] to reduce inappropriate critical values and unnecessary strain on both laboratory and clinical resources. Both the marginal resource cost and the marginal clinical utility should be carefully considered before tests are performed, and these factors should be considered when determining the threshold for critical value reporting.[9,12,13] In addition, it's worth noting that clinicians must follow the protocol of critical value system in evaluating lab parameters. Unless we do, we may miss the best timing of intervention and cause deadly consequence.[1]

Dighe et al[6] reported that potassium, partial thromboplastin time and platelet counts were the leading sources of critical values. As shown in Table 3, neonatal critical value reports were most frequently made in NICUs. The leading sources of neonatal critical values in the present study were routine coagulation tests, imaging tests and glucose disorders. These differences may be related to age, race, and disease composition. Notably, pediatricians and nurses should take these different patient characteristics into consideration during treatment and have more concern regarding NICU infants to prevent such common critical values from being reported during the night shift and lunch break.

Our results differed from those of previous

publications[2,6] regarding age, location, disease pattern and specialty. However, because few publications have focused on neonatal critical values, comparing our criteria and results to those of other studies was difficult. As reported by Adamkin et al,[14] glucose homeostasis is a common problem in newborns. For example, the risk of neonatal hypoglycemia is higher for infants who are born small for gestational age, and newborn infants of mothers with preexisting overt diabetes mellitus are at risk for hypoglycemia.[15] Long-term neurological sequelae occur over a continuum of low plasma glucose values.[15,16] If we received a critical hypoglycemia report, we would perform glucose intravenous infusion immediately and repeated it 2-3 hours later. In the present study, all the infants in our center were transferred from other hospitals and therefore had a higher risk of hypoglycemia.

Thus, we set a relatively high threshold for critical hypoglycemia (<2.6 mmol/L) to avoid missed diagnoses. Hyperglycemia has been associated with increased morbidity, retinopathy of prematurity and intraventricular hemorrhage.[17-19] When we received a critical hyperglycemia report, the infant must be treated with intravenous insulin and limiting the intravenous glucose. However, there is a lack of consensus regarding the threshold level for the hyperglycemia critical value. In addition, blood sugars >12 mmol/L have been considered as severe hyperglycemia in nearly all previous studies.[20] Our center has no hyperglycemia critical value, which may indicate that the threshold of critical hyperglycemia in our center was unreasonable. Don-Wauchope et al[12] reported plasma glucose thresholds for newborns <3 days of age as ≤1.7 mmol/L and ≥16.7 mmol/L, which vary from those for newborns >3 days of age (≤2.5 mmol/L and ≥20 mmol/L). Therefore, our center plan to set ≥16.7 mmol/L as the new threshold for the hyperglycemia critical value, and we must pay more attention to glucose homeostasis in high-risk newborns.

When a critical value is reported, the doctor should not only take corrective actions but also summarize the clinical experience to develop appropriate treatment plans for these high-risk newborns, especially those in the NICU. For example, if we receive the report of pneumoperitoneum from imaging department, we should ask the department of gastrointestinal surgery for urgent consultation and make preparation for emergency operation. Furthermore, each newborn center needs to enact rapid treatment guidelines to address common critical values to facilitate emergent clinical interventions in the shortest period of time. As our laboratory staff identified many false-positive critical values before reporting them, this survey showed a lower occurrence of critical values than those reported in other studies.[2,3,6] Furthermore, the blood gas analyses, blood glucose tests and many imaging tests were primarily performed at the bedside. When these tests revealed an abnormal result, the technician notified the physician in person to take corrective action immediately, which shortened the callback time. In other words, performing certain tests at the bedside may be a good method for reducing clinical reaction time and improving patient safety.

In the present study, we showed that routine coagulation tests and blood cultures were common sources of critical values in newborns, but these tests also had the lowest positive impact on treatment and management rates (26.5% and 42.3%, respectively). The main reason for this result is that there is often no need to perform additional treatment when a critical value report is received, as interventions may have been initiated before the critical value was reported.

Periodically summarizing the characteristics of critical values could help adjust the criteria,[10] which may also help set routine therapeutic strategies. For example, if we receive a critical coagulation test report, we should apply hemostasis drug or fresh-frozen plasma within 15 minutes. Further, the previous criteria for routine coagulation tests at our center were "PT>60 s, APTT>80 s, Fib<0.5". We received 3-10 critical coagulation test reports every day with the old criteria, but more than 90% of these reports had no impact on treatment. Unfortunately, this situation decreased pediatrician's vigilance regarding this critical value. Thus, we adjusted this critical value to "PT>180 s, APTT>240 s, Fib<0.5" (maximum range of our instrument). Using the updated criteria during this period not only reduced the number of critical values by more than 500 (approximately 66% of the total) but also increased physician awareness without raising the incidence of intracranial or intracerebral hemorrhage (data not shown). Therefore, the pediatrician should perform certain routine interventions (i.e., hemostatic treatment) before obtaining test results and then adjust the therapy after receiving test results. The critical value system is very important and useful for neonatal intensive care. Periodically summarizing the characteristics of the critical values could guide the adjustment of the criteria for the values. In turn, this could affect the determination of routine therapeutic strategies.

After obtaining a critical value suggesting that a newborn was in imminent danger, appropriate therapy was initiated promptly; however, in some cases, treatment had already been initiated before these critical values were obtained. For example, a physician can

be notified of a critical value for a high-risk preterm infant during a routine coagulation test following the administration of proprietary hemostasis drugs or even fresh frozen plasma upon admission. In other cases, positive blood cultures usually indicate that the physician should isolate the patient, take measures to disinfect the patient or change the antibiotics being administered. In fact, there is growing interest in disinfection and isolation in our department, and our empirical antibiotic therapy is usually effective. Therefore, providing extra treatment to patients with certain critical values is not necessary in clinical practice. In addition, our empirical antibiotic therapy relies on a quarterly blood culture monitoring report. Therefore, strict disinfection-isolation systems and blood culture monitoring reports could improve the management of newborn safety. This finding also indicates that we should combine laboratory results and clinical data before taking action and initiate treatment based on clinical experience without waiting for test results associated with common critical values.

Hemolyzed specimens are a rather frequent occurrence in laboratory practice, and it's a common cause of false-positive critical values.[21,22] In most cases they are due to preanalytical sources related to incorrect procedures or failure to follow procedures for collection, handling and storage of the samples.[21] In this study, the rate of treatment intervention following a serum potassium critical value was 67.3%. The only reason for these false-positive values was specimen hemolysis without any clinical symptoms of hyperkalemia.[23] Further, modern methods of medical examination can easily lead to neonatal iatrogenic anemia;[24] therefore, it is always difficult to repeat tests associated with critical values. Even though samples were labeled as having hemolysis, the lab reported all the critical values to the ordering location. Only the infants who had clinical symptoms of hyperkalemia were subjected to blood re-collection to repeat the tests, so we only re-collected 6 infants' blood samples to retest. In addition, all of the 6 patients were still with serious hyperkalemia after the retests. This condition was considered to have a "positive impact" on treatment. Consequently, improving specimen quality may be a good way to decrease false-positive critical values and to avoid neonatal iatrogenic anemia.[25,26]

Critical value systems have many stringent requirements that could improve neonatal intensive care. For example, they provide timelines for the turnaround time for tests, for calling the ordering location and for initiating treatment. Furthermore, the interval between critical values in the same patient for the same analyte is very important for deciding whether to report the repeat critical values.[6] If the intervals are short, the same pediatricians are on shift and are knowledgeable regarding the patient's condition, and the intervention may have been performed when the first report was received. Thus, it may not be necessary to report all the repeat critical values.[2]

About one third of all the critical value reports were deemed to be unnecessary because they had a negative impact on treatment. An unnecessary call would take a technician 2-3 minutes to call the pediatrician, and then the pediatrician would take 2-10 minutes to check whether the infant was in a critical state. So it's very important to reduce the proportion of unnecessary reports. We plan to establish an individualized reporting strategy aimed at coagulation tests. Based on the median interval,[2] if the results are not worse, we'll consider it acceptable to not call repeat critical values of coagulation tests within 12 hours.

Our department is among the busiest newborn tertiary centers in China. The critical values system helps our center avoid the sudden death of critically ill infants. Thus, we believe that our findings can be applied to critical neonates in large neonatology departments in developing countries. Due to the unique characteristics of the setting, our findings may not be applicable to small or rural hospitals in developed countries. To the best of our knowledge, this is the first report of neonatal critical values from the perspective of pediatricians in China and is one of very few such reports internationally.

This study has potential limitations, including its single-center design and short duration. The clinical data used to update the critical value list were collected for only five months. Although the present study described some characteristics of neonatal critical values, our results should be interpreted with caution. The ranges of certain items on the critical value list may be inappropriate, such as the blood glucose and the hemoglobin and platelets ranges. Serum bilirubin should be added to the list of neonatal critical values. We are planning to update some of these ranges to facilitate clinical interventions and ultimately improve outcomes. Additional research employing multiple centers with longer durations is needed to provide more reliable clinical data for developing appropriate critical value lists and ranges.

In conclusion, premature infants and those in the NICU had a higher risk of having a critical value. It's necessary for each center to have a policy on how to handle the common critical values urgently, especially during the peak hours of critical values, the night shift and lunch break time. Laboratories should improve specimen quality, set reasonable thresholds and reduce certain repeated critical value calls to decrease unnecessary reports.

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Contributors: Yu JL and Du LZ conceived and designed the study;Wang ZL and Chen YY performed the study and wrote the manuscript. Li LQ, Lu Q and Liu Y analyzed and interpreted the data. Cao LY, He Y revised the manuscript. All authors read and approved it for publication.

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