International Journal of Science and Healthcare Research
Vol. 9; Issue: 3; July-September 2024
Website: ijshr.com
Case Report *ISSN: 2455-7587*

Lightning Injury: Case of a 7-Year-Old Child Struck by Lightning in Region 8 Guyana

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DOI: https://doi.org/10.52403/ijrr.20240348

ABSTRACT

Background: It is estimated that lightning occurrence frequency worldwide is 50 occurrences per second with 20% of those resulting in ground strikes. It is estimated that approximately 24,000 fatalities occur worldwide due to lightning strikes and in the US 25-50 patients die each year. The mechanisms of injury due to lightning strike are numerous which includes the effects of the electrical current passing through body tissue, burns and mechanical trauma. Cardiac and respiratory arrest are more common with direct lightning strikes and may lead to sudden death.

Case Presentation: Here we present a case of child who was struck by lightning in a hinterland region. The child was found in an unconscious state by a passerby. He was then taken to a local health post where he regained consciousness. Initial vitals were stable, and child appeared to have suffered burns about the body. Arrangements were made and he was air dashed to GPHC. He was alert with stable vitals when he arrived, appeared to have suffered minor burns about the body. His ECG, X rays and CT head were all normal. He had an elevated CPK level which caused concern for Rhabdomyolysis. He was admitted to the paediatric ward.

Outcome: The child spent 3 days on the ward, where he was monitored closely for any delayed complications related to lightning injuries. His CPK had normalized, he received dressings for his burns and was subsequently discharged home.

Keywords: Lightning Strike, Lightening Injuries

INTRODUCTION

Lightning strikes, while visually captivating, pose serious threats to human health, often resulting in a range of injuries that demand specialized medical attention. In this exploration, we shift our focus to the medical intricacies of lightning strikes, unravelling the physiological effects on the human body, the diverse array of injuries incurred, and the complexities faced by medical practitioners in diagnosing and treating lightning-related casualties.

LITERATURE REVIEW

Lightning is an electrical discharge or current which occurs between positively and negatively charged regions of a cloud.[1] These discharges serve as a process of equalization and have been documented to travel between cloud to ground, cloud to cloud or cloud to air. Stokes is the term applied to the visual aspect of lightning while sonic shock wave is the phrase used to describe the sound heard. [1] A single bolt of lightning can travel at a speed of 45 km/s (kilometres per second), can reach temperatures of up to 28,000 C, carries an electric current of 40-120 kA (kilo amperes)

and can transfer a charge of 5 coulombs and 500 MJ (megajoules).[2] Lightning can be both positively and negatively charged with a variation of alternate and direct current. A patient's exposure typically lasts 1/1000 to 1/10 of a second. 5% of occurrences are due to direct strikes, contact injuries occur by touching a struck object, while side splash occurs when the current jumps from an object to patient. [3,4]

It is estimated that lightning occurrence frequency worldwide is 50 occurrences per second with 20% of those resulting in ground strikes.[3] It is estimated that approximately 24,000 fatalities occur worldwide due to lightning strikes and in the US 25-50 patients die each year.[3,5] The mechanisms of injury due to lightning strike are numerous which includes the effects of the electrical current passing through body tissue, burns and mechanical trauma.[3, 5-6] Cardiac and respiratory arrest are more common with direct lightning strikes and may lead to sudden death.[3,7] The strike may cause depolarization of the myocardial cells which lead to asystole, ventricular arrythmias may occur, however are less common. Return of spontaneous sinus rhythm may occur with sinus bradycardia being the most prevalent. There is also a risk of a recurrent arrest due to paralysis of the medullary respiratory centres. [3]

Lightning also affects the nervous system causing intracranial haemorrhage specifically in the basal ganglion and brainstem centres. [3,8] A temporary paralysis may occur due to vascular spasms and instability of the sympathetic nervous system, most commonly in the lower extremities, termed Keraunoparalysis. [3,7-9]

Varying types of burns occur in patients who have suffered a lightning strike, ranging from superficial to full thickness. [3,10] As lightning travel over the skin sweat vaporizes leading to partial thickness linear burns while punctate are clustered and circular as the current passes from deep tissues. [3,10] Full thickness burns are rare and may be due to superheated metal or fabric on patient' skin. [3,10]

Ophthalmic injuries are common as light inducing cataracts being the most frequently observed sequelae and may form weeks or years after the injury. [3,7-8] Other common ocular finding includes hyphema, vitreous haemorrhage, corneal abrasion, uveitis, retinal detachment or haemorrhage. [3,7-8] Blast effect may also lead to tympanic membrane rupture, sensorineural hearing loss, ataxia, vertigo, and nystagmus. [7,8]

Blunt trauma may also occur as a result of electrical current leading to massive instantaneous contraction of muscles resulting in patient receiving a shock wave due to temperature change of the bolt. [3] This shock wave has been linked to the concussive injuries, pneumothorax, tympanic membrane rupture, organ contusion and severe trauma due to falls. [3] Patient can also be hit by objects which can result in a multitude of trauma presentations including but not limited to spinal fractures. [3,8]

According to Cline et al., (2015) rhabdomyolysis after lightning strike is unusual, however, studies and case reports have documented the occurrence of severe renal failure due to the development of rhabdomyolysis. Rhabdomyolysis is a disorder denoted by acute damage to scleroderma of skeletal muscle leading to excessive release of creatine phosphokinase and myoglobin in conjunction with myoglobinuria. [11,12] Within the literature myoglobinuria and rhabdomyolysis are described as the same entity and as such a few case reports and studies have documented this occurrence. [12-14]

CASE PRESENTATION

A seven-year-old child was referred from a health centre in a remote village located in Region 8 (Pataro-Siparuni) Guyana. The referring health worker stated in his notes that the child had been supposedly struck by lightning around 16:45 hours. The child had loss of consciousness for approximately 10-15 mins, he had burns on his face and torso and one episode of bloody vomit. He noted that the child complained of lower back

pains as well. His vitals at the health centre were HR: 88 bpm, Temp: 36.6° C and Resp: 24 bpm. Child was given dimenhydrinate 25mg IV, Tabs Panadol 250mg po and 300ml Normal Saline bolus.

The child and mother were airlifted to Eugene F. Correira Airport and subsequently transferred to Georgetown Public Hospital Corporation. The EMTs noted the child's vitals during transport as follows HR: 88 bpm, Temp: 98.6° F, Resp: 24, RBS: 112 and GCS: 15/15. In the emergency department the child was triaged with the following vitals HR: 94 bpm, Temp: 98.9° F, SpO2: 97% on RA, Resp: 22. He was conscious, alert, and oriented to time, place and person. The child was triaged as Urgent an ECG was ordered (Figure 1) and seen by an Emergency Physician.

The mother refers that the child was at a neighbouring village earlier in the afternoon and was expected to return home later that afternoon. For him to arrive home, he would have to walk a few miles across an open savannah. She noted that he did not arrive at his usual time and someone brough him home in an unconscious state. She noticed that all his clothing were ripped up and they were discoloured. He had bruising on his face and body as well. He subsequently regained consciousness at home where he had one blood-tinged vomit, and she subsequently took him to the health post.

The child stated that he was walking through the savannah, and he cannot remember anything that happened to him. The last thing he remembered was walking home and then waking up at home. He complained of pains to his face, chest, abdomen, and genitalia. He also complained of pains to his left eye. He denied feeling nauseated or dizzy. No headaches or blurry vision or hearing impairment. He was fully vaccinated, live with his mother, two other siblings, no sick contacts and had no illness prior. He had no past surgical history and no allergies.

On physical examination, generally the child appeared well, speaking in full sentences, trachea was central with bilateral air entry and bounding peripheral pulses. He was conscious, alert, and oriented to time, place, and person as well as ambulant. When looking at his HEENT exam it was noted that he had erythema to the left eye lateral aspect of the conjunctiva, not violating the limbus (Figure 2), visual acuity was intact bilaterally, normal range of motion of the eyes, pupils were 2mm equally reactive to light and had no hyphema. His ear, nose and throat exam were normal. Visual inspection of the face and lips revealed raised erythematous desquamations and blebs extending from left lateral commissure of the lips, left aspect of the cheeks and anterolateral portion of left mandible (Figure 3), indicative of superficial and superficial partial thickness burns respectively. There were also small < 0.1 cm blebs to right commissure of lips (Figure 4). Visual inspection of the neck revealed a longitudinal superficial partial thickness burn measuring 5cm extending from left lateral aspect of zone 2 (Figure 5).

External examination of the chest revealed a large diagonal superficial and superficial partial thickness burns extending from left midclavicular line to the right anterior superior iliac crest (Figure 5 and 6), length 24cm and with 6cm. Chest was tender to palpation especially over the burnt areas, he had bilateral air entry with no crepitations or wheezing on auscultation. Heart sounds were present and normal, capillary refill was less than 2 seconds. The burnt area described above extended across the abdomen, hence tenderness was elicited on palpation of that area. Bowel sounds were present and normal, no organomegaly noted. Parent did not consent to a digital rectal examination. Examination of the genitalia revealed superficial burns to scrotum 2cm x 2cm on the inferior portion, left lateral to the raphe (Permission was not granted for the use to genitalia pictures). Penis was normal and patient had no issues voiding. Examination of the back and gluteus were normal. Bilateral upper extremity

examination was normal. Left lower extremity examination was normal, however the right thigh examination revealed superficial partial thickness burns extending from greater trochanter area to lateral mid-thigh as well as posteriorly (Figure 7). Neurological examination was completely normal.

The emergency physician orders were complete blood count, renal function and electrolytes, CK-MB and CPK and Urinalysis (Table1). Trauma series x-ray (Figures 8 and 9) were ordered as well as a plain CT of the head (Figure 10). An EFAST was performed and was noted to be normal. The working differential diagnosis included 1. Superficial and Superficial partial thickness burns due to lightning strike (6% TBSA for Superficial Partial Thickness burns), 2. Rhabdomyolysis, 3. Traumatic Brain Injury, 4. Electrolyte Imbalance. He was given Panadol 250mg and 300 ml Normal Saline bolus. The disposition plan was to have the Paediatric Medicine and Burns Unit on call team review the child for admission and further evaluation and monitoring.

The child spent approximately 3 days admitted to the open paediatric ward. He was monitored closely for complications. During this period his neurological status was documented as normal, he received daily dressing for his burns, his visual examination was normal, and his vitals remained stable. His repeated labs including his CPK normalized (740-155). The child received dressings for his superficial burns, and he was subsequent discharged.

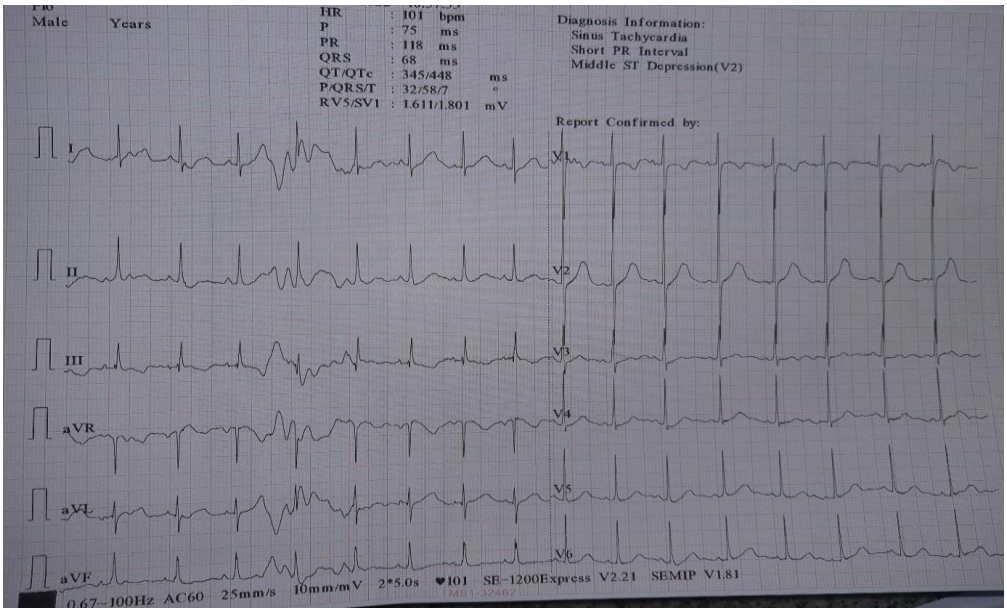


Figure 1: Electrocardiogram obtained in triage

Figure 2: Showing left eye with erythema (Image used with parental permission)

Figure 3: Showing raised erythematous desquamation and blebs (Image used with parental permission)

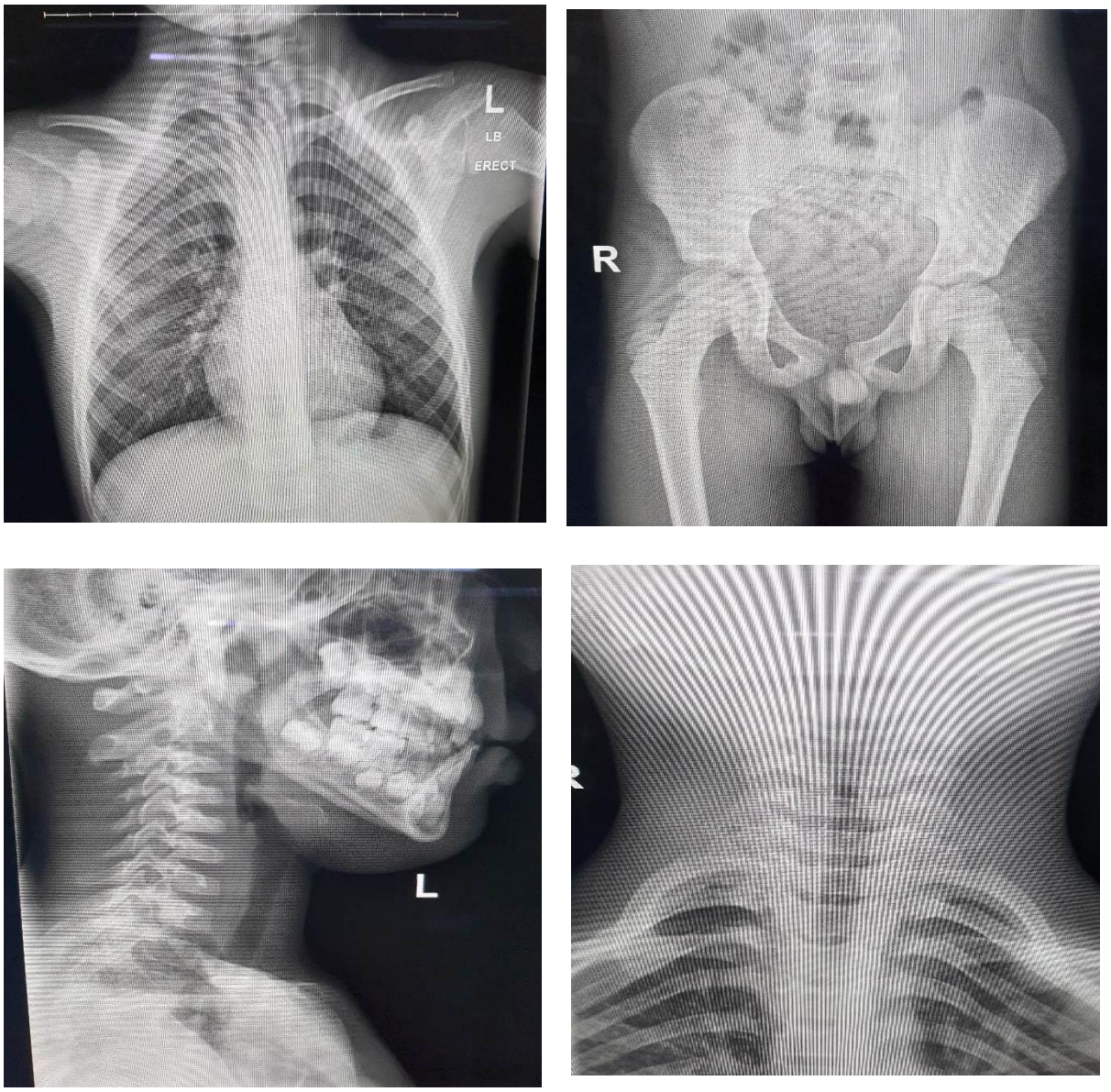
Figure 4: Showing small blebs at the right lip commissure, erythematous desquamations with dry flaky appearance or left maxillary and mandibular areas (Image used with parental permission)

Figure 5: Showing burns to chest and abdomen (Image used with parental permission)

Figure 6: Showing burns to right flank and right upper thigh (Image used with parental permission)

Figure 7: Superficial partial thickness burns to right anterolateral and posterior thigh

A **B**



C **D**

Figure 8: A Normal Chest X-rays, B Normal Pelvic X rays, C & D Normal C-spine X rays

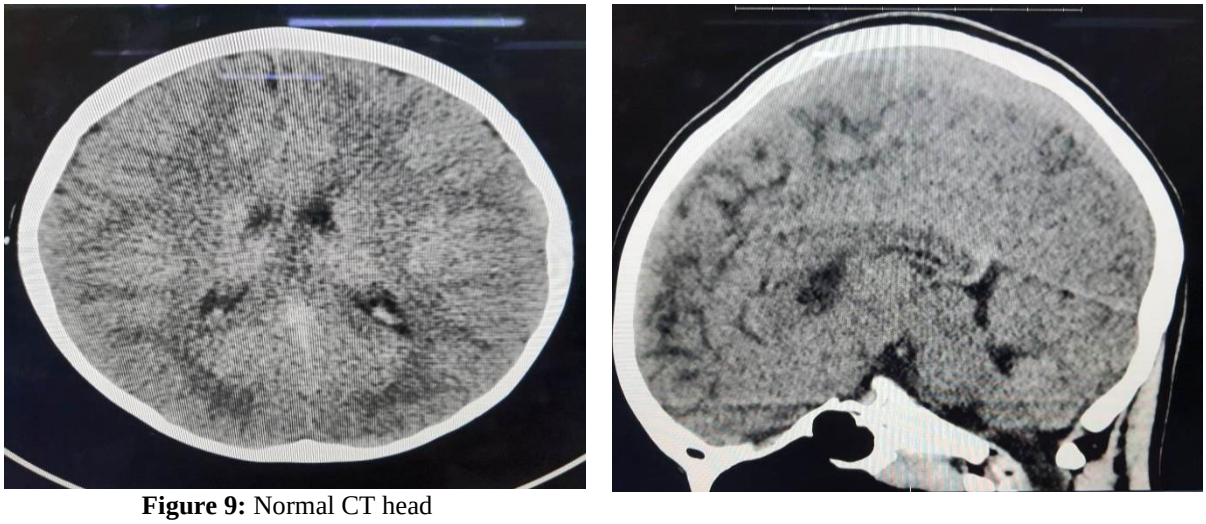


Figure 9: Normal CT head

DISCUSSION

Lightning strikes pose a unique set of challenges to medical professionals due to their unpredictable nature and the diverse range of injuries they can cause. Three to four percent of all burn-related injuries are caused by electrical burns and lightning injuries, which cause more than 3000 admissions to specialist burn units annually in the United States. [15] An estimated 1000 people die year from major electrical injuries, up to 40% of which are fatal. [16] Over 90% of casualties are men, and around two thirds of all electrical injuries are caused by construction and electrical workers combined. Male children are twice as likely as female youngsters to sustain accidental electrical injury. [17] The mechanism and degree of harm are affected by a number of factors, including voltage, tissue resistance, current type (DC or AC), current pathway, length of contact, and amount of current passing through the body. [18]

Because lightning strikes are DC exposures that last between 1/10 and 1/1000 of a second and frequently have voltages that reach 10 million V, they produce unique phenomena and mechanisms of harm. [19] Lightning is a naturally occurring electric arc. There are 4 main mechanisms by which lightning current can be transmitted which include direct strike, contact strike, side-flash or splash and ground strike. Given that this child was walking in a savannah area which is mostly flat grasslands, he could have been a victim of a direct strike or a ground strike i.e. where the lightening hits the ground and is carried to the victim. [20] There are a few phenomenon that are unique lightning strikes which includes Flashover effect, Keraunoparalysis, Autonomic dysfunction and Secondary trauma. [21]

In this case it can be posited that the child may have been a victim of the flashover effect since this describes a strong current that is quickly spread throughout the skin, frequently made easier by the skin's reduced ability to withstand moisture from perspiration or rain. The child did not appear to suffer any of the immediate cardiac or neurological effects of a lightning strike; however he did suffer a great deal of skin related injuries as can be seen in the images. He had had what is described as electrical flash burns and burns to the face sparing his oral mucosa. The deep tissues encircling long bones frequently suffer the most electrothermal damage following a high-voltage exposure (apart from lightning). When an electrical current is applied to bone, it produces the most heat of any bodily tissue due to its high resistance. It is possible to develop osteonecrosis, periosteal burns, and bone matrix degradation. Because of the very brief exposure time, deep tissue injuries from lightning strikes are rare. [22] Deep electrothermal injury can cause tissue necrosis and edema and result in a compartment syndrome. Massive tissue necrosis can then cause rhabdomyolysis and/or visceral injury which was major concern in this child's case since he had elevated CPK levels. There was also concern for secondary trauma from the blast effect, however the CT head and x rays ruled out any acute blast injuries.

CONCLUSION

Lightning strikes, with their captivating yet perilous nature, pose a unique set of challenges for the medical community. The physiological effects on the human body, the diverse range of injuries incurred, and the complexities in diagnosing and treating lightning-related injuries demand a comprehensive and interdisciplinary approach. From immediate cardiac and neurological consequences to long-term physical and psychological effects, the impact of a lightning strike extends far beyond the initial encounter.

Declaration by Authors

Ethical Approval: Not applicable
Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Vedprakash Etwaria, Jenell Cadogan. Lightning injury: case of a 7-year-old child struck by lightning in region 8 Guyana. *International Journal of Research and Review*. 2024; 11(3):390-400. DOI: *https://doi.org/10.52403/ijrr.20240348*

Appendix

Table 1: Initial Lab values

LABS	VALUES	NORMAL RANGES
HB	13.1 g/dl	3.00-12.00
HCT	43.6%	35.0-49.0
RBC	5.47 x 10^12/L	4.50-5.30
MCV	79.6 fL	77.0-94.0
MEAN CORPUSCULAR HAEMOGLOBIN	23.8 pg	27.0-34.0
MEAN CORPUSULAR HB COOUNT	29.9%	32.0-36.0
RDW	12.2%	11.5-14.5
WBC	16.1410^9 /L	3.00-12.00
NEUTROPHILS	79.33% 12.80x10^9/L	1.05-7.90
LYMPHOCYTES	13.47% 2.17x10^9/L	0.66-5.10
EOSINOPHILS	0.59% 0.10x10^9/L	0.00-0.60
BASOPHILS	0.69% 0.1x10^9/L	0.0-0.2
MONOCYTES	5.92% 0.96x10^9/L	0.00-0.90
PLATELETS	368 x 10^9/L	150-450
BUN	6.20 mg/dL	7.00-18.00
CREATININE	0.5 mg/dL	0.4-1.0
SODIUM	143.80 mmol/L	135.00-148.00
POSTASSIUM	3.39 mmol/L	3.50-5.30
CHLORIDE	106.80	98.00-107.00
CK-MB	55 U/L	0-24
CPK	740 U/L	<160
URINE MICROSCOPY	Bacteria 1+	
COLOUR	Straw	
CLARITY	Clear	
GLUCOSE	Negative	
BILIRUBIN	Negative	
KETONES	Negative	
SPECIFIC GRAVITY	1.005	
BLOOD	Negative	
PH	6.5	
PROTEIN	Negative	
UROBILIONGEN	Normal	
NITRATE	Negative	
LEUKOCYES	Negative	

Table 2: Repeated lab values

LABS	RESULTS	RANGES
BUN	Reagent Stock out	7.00-18.00
CREATININE	0.4 mg/dL	0.4-1.0
SODIUM	139.90 mmol/L	135.00-148.00
POSTASSIUM	3.68 mmol/L	3.50-5.30
CHLORIDE	105.10 mmol/L	98.00-107.00
CPK	155	<160

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