



ELECTROCARDIOGRAPHIC PATTERN IN CHILDREN WITH LASSA FEVER

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ABSTRACT

Lassa fever is a highly contagious and multisystem disease endemic in parts of the West African sub region. There is paucity of data on the electrocardiographic pattern in children with Lassa fever. In this study our aim is to document as seen in the children with Lassa fever in Irrua Specialist Teaching Hospital (ISTH), a tertiary institution in South-South Nigeria, in this study. The study was a prospective cross sectional study of 41 children aged 1-16 years with Lassa fever and 41 age and sex matched controls with fever from other causes recruited from the Lassa fever isolation ward and the Paediatric ward of ISTH Irrua, respectively. The cases and controls were assessed clinically and their cardiovascular functions were evaluated using a 12 channel electrocardiograph (ECG). Data obtained were analyzed using appropriate analytical tests.

A total of 82 children aged 1-16 years were recruited for the study. Forty one of them had Lassa fever and 41 age and sex matched controls had fever from other causes. Out of the 41 cases with Lassa fever, 32 (78.1%) had abnormal ECG findings while only 15 (36.6%) of the control group had abnormal ECG findings ($X^2= 12.8, p= 0.0004$). The difference was statistically significant. The abnormalities were more in the male patients with Lassa fever (84%) and in the male controls (60%). The commonest ECG abnormalities in the Lassa fever cases were arrhythmias (31.7%), prolonged QTc (29.3%) and ST segment /T wave changes (22%). However, in the controls the commonest abnormalities were arrhythmia (17.1%), left ventricular hypertrophy (7.3%) and aberrant ventricular complexes (7.3%).

Electrocardiographic changes are common in children with Lassa fever; the commonest findings are arrhythmia (31.7%) and prolonged QTc (29.3%)

Index Terms: ECG abnormalities, prolonged QTc, Lassa fever, arrhythmia

INTRODUCTION

Lassa fever is one of the viral haemorrhagic fevers. It is endemic in the West African sub-region (Nigeria, Guinea, Liberia, Sierra Leone) and was first described in 1969 in the town of Lassa in Borno State in Northern Nigeria^{1,2}

Lassa fever is transmitted to humans through contact with food or other items contaminated with urine or faeces from the natural reservoir which are multimammate rats (*mastomys natalensis*)¹. Transmission of Lassa virus to humans occurs most commonly through ingestion of contaminated food, inhalation and consumption of the rats as food by people especially children.³ Human to-human transmission also occurs through contact with infected persons' secretions or through vertical transmission from mother to child.⁴

Lassa fever begins after 7–18 days of incubation with different presentations that mimic the common tropical illnesses like malaria, typhoid fever and even sepsis, but fever seems to be a constant feature.^{4, 5} Other symptoms include headache, malaise, sore throat, retrosternal or epigastric pain, vomiting, conjunctivitis, cough and mucosal bleeding.⁶

Paediatric patients with Lassa fever have also been shown to present with acute abdomen, convulsive episodes or in severe disease, clinical features of a swollen baby syndrome which is characterized by widespread edema, abdominal distention, and bleeding.^{4,7}

The Lassa virus is hepatotropic, lymphoreticulotropic, pneumotropic and myocardiotropic^{8,9}. The effects are therefore pan systemic.^{6,7} Some of the cardiovascular presentations of Lassa fever include cough, retrosternal pain and chest pain. Signs of increased vascular permeability such as facial oedema or pleural effusion are present in a minority of patient, and the illness may progress to shock and death of the patient.⁹

About 20% of patients have been reported to have pleural or pericardial rubs late in the disease or at the beginning of convalescence, with pericarditis occurring particularly in male patients.^{6, 9} Recurrent pericarditis with constriction, polyserositis and myocarditis have also been documented.^{9, 10, 11}

Chest radiography may show infiltrates and pleural effusions. Electrocardiographic findings have been reported to be nonspecific.^{8,9} A study by Cummins et al on 32 patients, aged 15-70 years, with acute Lassa fever showed that 70% of the patients had ECG abnormalities. The abnormalities noted were nonspecific ST segment and T-wave changes, ST segment elevation and generalized low voltage complexes.

Electrocardiographic abnormalities in some viral infections like dengue fever and Covid-19 have been extensively documented^{12, 13, 14} but there is a dearth of data on the ECG abnormalities in children with Lassa fever. This study is aimed at documenting these abnormalities.

RESEARCH METHODOLOGY

The study was a prospective study conducted in Irrua Specialist Teaching Hospital in Edo State, a tertiary institution, in South-South Nigeria. Forty one children aged 1-16 years with positive Lassa virus polymerase chain reaction (PCR) test who were on admission in the Lassa isolation ward were consecutively recruited for the study over a period of 26 months. The controls were age and sex matched children admitted into the Paediatric ward with febrile illnesses not caused by Lassa virus. Children in the control group with anaemia, heart failure, congenital or acquired heart disease and electrolyte imbalance were excluded from the study. The biodata of each child was obtained and each child was examined clinically.

The investigations conducted on the cases diagnosed with Lassa fever and the controls were complete blood count, serum electrolyte, urea and creatinine. The cardiovascular function of each child was assessed using a 12 channel electrocardiograph (ECG), BeneHeart R12 machine within 72 hours of admission.

The children were categorized into 5 groups: 1<3 years, 3<5 years, 5<8 years, 8<12 years and 12<16 years, in line with the expected ECG changes with age.¹⁵ The ECG parameters were read from the ECG tracings guided by the normal reference standards.¹⁵

The ECG parameters checked were rhythm, rate, frontal plane axes of the QRS and T waves, PR interval, QRS duration, QTc, P wave duration and amplitude, ST elevation or depression and T wave changes. Data recording and analysis were carried out using Microsoft Excel programme 2007 and OpenEpi.

RESULTS

A total of 82 children aged 1-16 years were recruited for the study. Forty-one were Lassa PCR positive and comprised of 25 males and 16 females; M: F ratio= 1.6:1. The mean age was 9.4±2.4 years. There were also 41 controls which comprised 19 males and 22 females; M: F ratio=1:1.2, the average age of the controls was 8.66±4.19. The largest numbers of patients in the study were children in the 12<16 year age group with 11 males and 4 females among the cases and 6 males and 8 females among the controls. There were more males among the Lassa patients (60.9% vs. 39.1%) and more females among the controls (64% vs. 46%).

There was a statistically higher number of ECG abnormalities among the Lassa fever cases than in the control (78.1% vs 36.6%, $X^2=12.76$, $p=0.0003$). Table 1 shows the distribution of abnormal ECGs according to the age and sex in the cases. The ECG was normal in 9 patients (21.9%) and abnormal in 32 patients (78.1%). The rate of ECG abnormalities was higher in males than females (21/25 (84%) vs. 11/16(68.8%) ($p=0.4$) but the difference was not statistically significant. The male patients below 8 years and the female patients below 5 years all had abnormal ECG recordings. There were eight males in the 1< 8 years age group. The clinical findings in these males were convulsion, sickle cell anaemia, anaemia from other causes and congestive cardiac failure. Among the three female in the 1<5 years age group the clinical findings included anaemia and congestive cardiac failure.

Table 1: ECG abnormalities according to age and sex among the Lassa fever cases

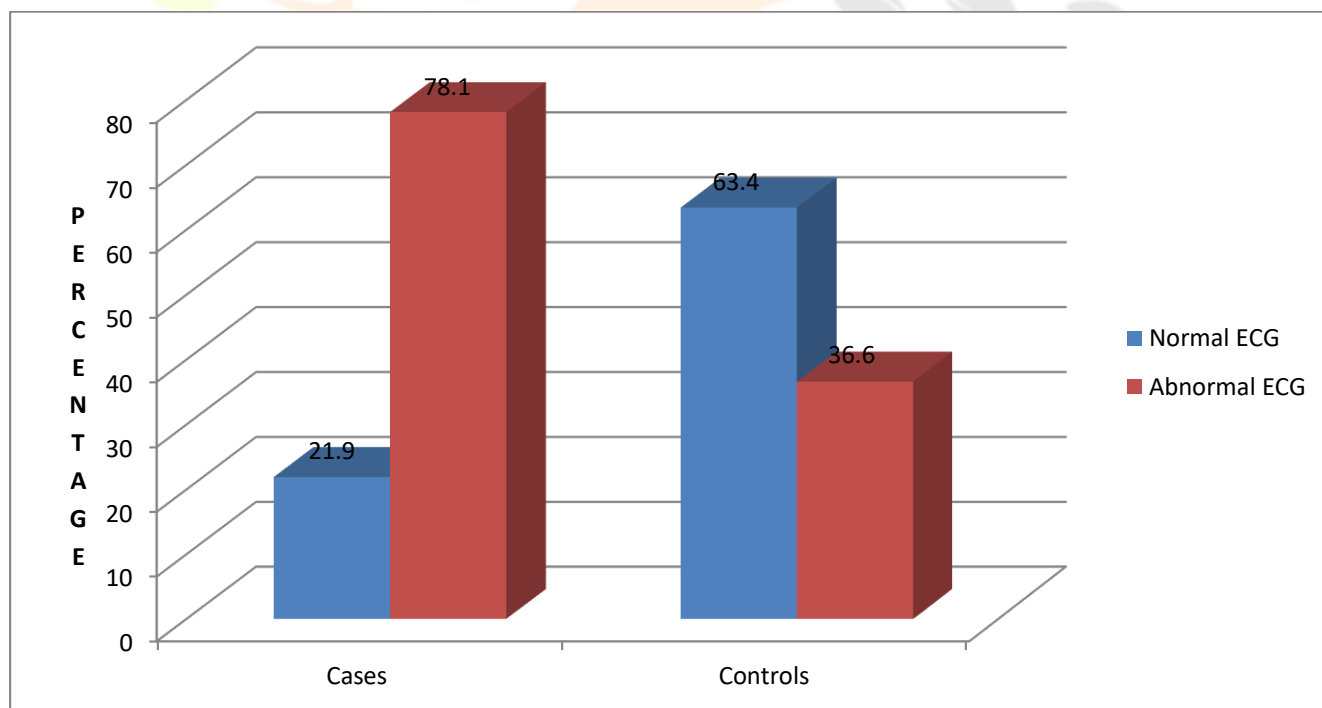
AGE RANGE (years)	NUMBER (%) WITH ABNORMALITIES		TOTAL NUMBER OF PATIENTS	TOTAL ABNORMAL ECG (%)
	MALE	FEMALE		
1< 3	1/1 (100%)	2/2 (100%)	3	3(100%)
3<5	2/2 (100%)	1 /1 (100%)	3	3(100%)
5<8	5/5 (100%)	1/3 (33.3%)	8	6 (75%)
8<12	4/6 (66.7)	4/6 (66.7%)	12	8(66.7%)
12<16	9/11 (81.81%)	3 /4 (75%)	15	12(80%)
TOTAL	21/25(84%)	11/16 (68.8%)	41	32/41(78.1%)

Table 2 shows the distribution of abnormal ECG according to the age and sex in the controls. The ECG was normal in 26 controls (63.4%) and abnormal in 15 controls (36.6%). The rate of ECG abnormalities was higher in males than females (9/19 (47.6%) vs. 6/22(27.3%) ($p=0.3$) The diagnoses in the controls included malaria, sepsis, cellulitis, urinary tract infection, bronchopneumonia, bullous impetigo, angioedema, acute suppurative otitis media, abscess and upper respiratory tract infection.

Table 2: ECG abnormalities according to age and sex among the controls

AGE RANGE (years)	NUMBER (%) WITH ABNORMALITIES		TOTAL NUMBER OF PATIENTS	TOTAL ABNORMAL ECG (%)
	MALE	FEMALE		
1<3	1/2 (50%)	0/3 (0%)	5	1(25%)
3<5	0/2 (0%)	0/2 (0%)	4	0(0%)
5<8	2/3 (66.7%)	1/3 (33.3%)	6	3 (50%)
8<12	2/6 (33.3%)	1/6 (16.7%)	12	3(25%)
12<16	4/6 (66.7%)	4/8 (50%)	14	8(57.1%)
TOTAL	9/19(47.6%)	6/22 (27.3%)	41	15/41(36.6%)

Fig 1 is a histogram showing the distribution of ECG abnormalities among the cases and controls. Nine cases (21.9%) had normal ECG readings, while 32 cases (78.1%) had abnormal ECGs. Twenty six controls (63.4%) had normal ECGs and 15 (36.6%) had abnormal ECGs.

**Fig 1: Frequency of ECG abnormalities in cases and controls**

The 32 cases with abnormal ECGs had a total of 52 abnormalities (Table 3) and the 15 controls with abnormal ECGs had a total of 25 abnormalities. Among the 32 Lassa fever cases with abnormalities, 14(43.8%) had one abnormality while 18(56.3%) had more than one abnormality. The commonest abnormalities were arrhythmia (31.7%) – tachycardia (22%), bradycardia (9.8%) and prolonged QTc (29.3%).

Four (26.7%) of the controls with abnormal ECG had one abnormality each while 11(73.3%) had more than one abnormality. The commonest abnormalities were arrhythmia (17.1%), aberrant ventricular complexes (7.3%) and left ventricular hypertrophy (7.3%).

There was a statistically significant difference between the cases with prolonged QTc and the controls ($X^2=6.97$, $p=0.008$). Though more Lassa fever cases had more of the listed abnormalities, the differences were not statistically significant (Table 3).

Table 3: Distribution of specific ECG abnormalities among the cases and the controls

ECG ABNORMALITIES	Cases n=41 (%)	Controls n=41 (%)	X ²	p-value
Prolonged QTc	12(29.3)	2(4.9)	6.97	0.008
Tachycardia	9(22)	7(17.1)	0.39	0.78
Bradycardia	4(9.8)	0(0)	2.36	0.12
Conduction delay/ Aberrant ventricular complexes	6(14.6)	3(7.3)	0.5	0.48
Prolonged PR interval	2(4.9)	2(4.9)	0.26	0.6
ST segment elevation	2(4.9)	2(4.9)	0.26	0.6
ST segment depression	0(0)	1(2.4)	NA	NA
T wave abnormalities	7(17.1)	2(4.9)	1.99	0.15
U wave	1(2.4)	0(0)	NA	NA
Left atrial enlargement	4(9.8)	2(4.9)	0.18	0.67
Right atrial enlargement	1(2.4)	0(0)	NA	NA
Left ventricular hypertrophy	2(4.9)	3(7.3)	0	0.99
Right ventricular hypertrophy	2(4.9)	1(2.4)	0.24	0.63
TOTAL	52	25		

Table 4 shows the ECG findings in three children (7.3%) with Lassa fever and in heart failure. The two males in this group were below 8 years of age and all had ECG abnormalities. All three children (100%) had tachycardia, 2(66.6%) had LAE and 1(33.3%) had prolonged QTc.

Table 4: ECG findings in the cases with heart failure

Age (years)	Sex	PCV (%)	ECG findings
2.5	F	41.6	Tachycardia, Left atrial enlargement (LAE), prolonged PR interval
3	M	33	Tachycardia, LAE, Prolonged QTc (0.49s)
7	M	26	Tachycardia

Six children (14.6%) in the study group were anaemic (PCV<33%)¹⁶ during the ECG assessment. Table 5 shows the age, sex and ECG findings in these children. Four (66.7%) of the patients in this group were males and of which 2(50%) were less than 8years. One child (16.7%) had a normal ECG while 3 children (50%) had prolonged QTc. One of the children with prolonged QTc had sickle cell anaemia. Two patients (33.3%) had tachycardia.

Table 5: ECG findings in Lassa fever cases with anaemia

Age (years)	Sex	PCV (%)	ECG findings
7	M	26	Tachycardia
7	M	27.2	Prolonged QTc (SCA)
7	F	32	Normal
14	M	32	Bradycardia ,Prolonged QTc
15	F	28	Tachycardia, Left atrial enlargement
15	M	32.2	Prolonged QTc, Prolonged PR interval

SCA- Sickle cell anaemia

There was no mortality recorded among the children who were recruited for this study.

DISCUSSION

Electrocardiographic changes due to myocardial injury have been reported in Lassa fever⁸ and other viral infections.^{12-14, 17, 18} This study was aimed at documenting the ECG changes in children with Lassa fever as seen in our center. The study showed that children with Lassa fever had a statistically higher prevalence of ECG abnormalities (78.1% vs 36.6%, $p=0.008$) than the controls. Cummins et al⁸ had earlier reported a frequency of 70% in patients with Lassa fever which is similar to the finding in this study though the patients in their study were mainly adults.

The commonest ECG abnormalities found in the Lassa fever cases in this study were arrhythmias (31.7%) (Tachycardia (22%), bradycardia (9.8%), prolonged QTc (29.3%) and ST segment/T wave changes (22%). In patients with Covid-19 infection the predominant ECG findings were arrhythmia (36.5%) (Tachycardia (23.8%), bradycardia (12.7%), long QTc (8.3%) and ST segment/T wave changes (32.4%).⁽³⁾ A study in children with dengue fever by Siddappa et al showed a preponderance of arrhythmia (30%) (Tachycardia (25%), bradycardia (5%) and T wave changes (17%).⁽¹⁰⁾ It is interesting to note that these are similar to the common changes found in this study. It could be that viraemia generally causes similar ECG changes in affected persons.

The specific ECG abnormalities in the cases and controls were similar, though more cases than controls had sinus tachycardia (22% vs 17.1%), sinus bradycardia (9.8% vs 0%), aberrant ventricular complexes (14.6% vs 7.3%), T-wave abnormalities (17.1% vs 4.9%), left (9.8% vs 4.8%) and right (4.9% vs 0%) atrial enlargements. The differences were, however, not statistically significant.

Electrocardiographic abnormalities were observed more in the males (84%) especially in those less than 8 years (100%). The high frequency of abnormalities among the younger males with Lassa fever in this study may be due to the presence of other clinical features in the patients like sickle cell anaemia, anaemia from other causes and congestive cardiac failure. Increased ECG abnormalities have been reported in children with these conditions.^{19, 20}

Three (7.3%) children in the study were in heart failure. Two (66.7%) of these children were males and less than 8 years. The abnormalities observed were tachycardia (100%), LAE (66.6%) and prolonged QTc (33.3%).

Six (14.6%) children with Lassa fever had anemia. Two (66.7%) of the three children less than 8 years in this group were males. The abnormalities found in the anaemic children were prolonged QTc (50%) and tachycardia (33.3%). These findings are similar to those reported by Odike et al in children with sickle cell anaemia and anaemia from other causes.^{19, 20} These clinical conditions may account for the increase in ECG abnormalities in the cases with Lassa fever.

Nine cases (21.9%) in the study had normal ECGs. This is similar to what was reported by Cummins et al⁸ (25%).

Electrocardiography can be used as an initial screening tool for myocarditis. The most frequent ECG findings in myocarditis are tachycardia, followed by ST/T wave changes.²¹ Tachycardia was recorded in 9(22%) patients and ST segment/T wave changes in 9(22%) patients. Myocarditis has been reported to occur in patients with Lassa fever.²² A previous study⁸ in Lassa fever patients aged 15-70 years reported a preponderance of non specific ST segment and/or T wave changes (69%), which is higher than was reported in this study. This may be due older age group used in their study.

Long QTc was noted in 29.3% of the patients and this was significantly higher than was seen in the controls ($X^2=6.97$, $p=0.008$). It is known to occur in acute myocarditis.^{23, 24} It can be used to prognosticate the outcome in patients with acute myocarditis. It is believed to be associated with increased risk of fulminant disease and in-hospital mortality.²³⁻²⁵ Identification of a long QTc interval is very important because it represents a well-known potential arrhythmogenic trigger.²⁴ Kaliyaperumal et al reported higher mortality in Covid-19 patients with QTc prolongation and tachycardia.¹³ The 12 patients in this study with Long QTc all recovered from the disease.

Bradycardia was present in 4 (9.8%) of the cases in this study. Bradycardia has been reported in pericarditis²⁶, dengue fever,^{17, 18} Lassa fever^{27, 28} and Covid -19 infection.²⁹ Bradycardia has also been documented with the use of Ribavirin, which is the drug of choice in the treatment of Lassa fever.³⁰ The 4 patients with bradycardia had no clinical manifestation of pericarditis but were on intravenous ribavirin. The only child in the study with a pericardial rub did not have bradycardia, but had anemic and heart failure. The only ECG abnormality he had was tachycardia. In this study 14.6% of cases had conduction delay/aberrant ventricular complexes (14.6%), conduction delay/ aberrant ventricular conduction (AVC) are most commonly caused by bundle branch block and ventricular hypertrophy.³¹ Two patients (4.9%) with AVC in this study had right ventricular hypertrophy (RVH).

Atrial enlargement was recorded in the children with Lassa fever (12.2%) and the most frequent was left atrial enlargement (9.8%). These enlargements have been reported in myocarditis, including atrial myocarditis.³² Atrial enlargement was also reported in 6% of the Lassa fever cases by Cummins et al, the left and right atria equally affected (3%).⁸

Prolonged PR interval was recorded in two (4.9%) patients. This has been reported in other viral infections.²³⁻²⁵ It may occur in ischemic heart disease, inflammatory and infiltrative diseases.³³ In this study, equal number of patients and controls had prolonged PR interval. It must be noted that the controls in this study were children on admission for febrile illnesses. The clinical conditions in these controls may also affect their ECG patterns.

One patient (1.9%) in this study and in the study by Cummins et al (3%) had a U waves.⁸ This can be seen in hypokalaemia and bradycardia.³⁴ The child with the U wave in this study had neither hypokalaemia nor bradycardia.

In conclusion, this study shows that ECG abnormalities are common in children with Lassa fever and the commonest abnormalities are arrhythmias and long QTc.

We recommend that the simple, non-invasive, bed side test like the ECG be used to monitor patients for cardiac manifestations of Lassa fever for necessary intervention.

REFERENCES

1. (Geneva WHO, Organization WH. Lassa Fever. Fact Sheet No 179. 2000) <https://www.cdc.gov/vhf/lassa/transmission/index.html> 3/2/23 11.32 am)
2. Ogunkunle et al. Infectious Diseases of Poverty (2020) 9:110 <https://doi.org/10.1186/s40249-020-00731-1>

3. Bonwitt J, Kelly AH, Ansumana R, Agbla S, Sahr F, Saez AM, Borchert M, Kock R, Fichet-Calvet E. Rat-atouille: A Mixed Method Study to Characterize Rodent Hunting and Consumption in the Context of Lassa Fever. *Ecohealth*. 2016 Jun;13(2):234-47. doi: 10.1007/s10393-016-1098-8. Epub 2016 Feb 19. PMID: 26895631; PMCID: PMC4996873.
4. Ogunkunle, T.O., Bello, S.O., Anderson, C.I. *et al.* Fatal case of newborn Lassa fever virus infection mimicking late onset neonatal sepsis: a case report from northern Nigeria. *Infect Dis Poverty* 9, 110 (2020). <https://doi.org/10.1186/s40249-020-00731-1>
5. Akpede G, Kayode-Adedeji B, Dawodu S Manifestations and outcomes of Lassa fever in Nigerian children: a case series *Archives of Disease in Childhood* 2012;97:A38-A39. <http://dx.doi.org/10.1136/archdischild-2012-301885.96>
6. J.B. McCormick, in *Encyclopedia of Virology (Third Edition)*, 2008 Lassa fever <https://www.sciencedirect.com/science/article/pii/B9780123744104004362> 5.35pm 6/2/23
7. Akpede GO, Adetunji AE, Udefiagbon EO, Eluehike SO, Odike AI, EwahOdiase RO, et al. Acute abdomen in pediatric patients with Lassa fever: prevalence and response to non operative management. *J Pediatr Infect Dis Soc*. 2019 ; 8(6):519–24.
8. David Cummins, Diana Bennett, Susan Fisher-Hoch, Bertha Farrar and Joseph McCormick. Electrocardiographic abnormalities in patients with Lassa fever. *Journal of Tropical Medicine and Hygiene* 1989, 92,350-355
9. Adewuyi G.M, Fowotade A. and Adewuyi B.T. LASSA FEVER: ANOTHER INFECTIOUS MENACE. *AFR. J. CLN. EXPER. MICROBIOL* 10(3): 144-155AJCEM/2008139/20917 -<http://www.ajol.info/journals/ajcem>
10. <https://medilib.ir/uptodate/show/103771> 9.45pm 01/01/24
11. Casals, J., Buckley, S.M. (1973). Lassa Fever Virus. In: Lehmann-Grube, F. (eds) *Lymphocytic Choriomeningitis Virus and Other Arenaviruses*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-65681-1_28
12. Parchani A, Krishnan Vs G, Kumar VKS. Electrocardiographic Changes in Dengue Fever: A Review of Literature. *Int J Gen Med*. 2021 Sep 14;14:5607-5614. doi: 10.2147/IJGM.S328755. PMID: 34548812; PMCID: PMC8449644.
13. Kaliyaperumal D, Bhargavi K, Ramaraju K, Nair KS, Ramalingam S, Alagesan M. Electrocardiographic Changes in COVID-19 Patients: A Hospital-based Descriptive Study. *Indian J Crit Care Med*. 2022 Jan;26(1):43-48. doi: 10.5005/jp-journals-10071-24045. PMID: 35110843; PMCID: PMC8783240.
14. Puljiz I, Kuzman I, Markotić A, Turcinov D, Matić M, Makek N. Electrocardiographic changes in patients with haemorrhagic fever with renal syndrome. *Scand J Infect Dis*. 2005;37(8):594-598. doi: 10.1080/00365540510036606. PMID: 16138429.
15. <https://ecgwaves.com/topic/reference-values-for-pediatric-electrocardiogram-ecg/> 9.20 am 6/2/23
16. World Health Organization: Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva: World Health Organization.; 2011. <https://www.who.int/vmnis/indicators/haemoglobin.pdf>. 28/06/24 9.22pm
17. Ivan T , Idar , Sudirman K , Syakib B , Haerani R , Pendrik T , Risna H , Hasyim K , Arifin S. Changes of Electrocardiography based on Disease Severity in Dengue Hemorrhagic Fever . *European Journal of Molecular & Clinical Medicine* ISSN 2515-8260 Volume 07, Issue 08, 2020 149
18. Abhinayaa J, James S, Jebaraj R, Vinoth PN. Incidence of Cardiac Manifestations in Children with Dengue Fever: A Cross-sectional Study. *Rambam Maimonides Med J*. 2021 Apr 29;12(2):e0014. doi: 10.5041/RMMJ.10436. PMID: 33938801; PMCID: PMC8092955.
19. Odike AI, Omokhodion SI, Akpede GO The Electrocardiographic profile in non-sickle cell anaemia children and sickle cell anaemia children. *Indian Journal of Basic and Applied Medical Research*; June 2018:Vol.7 (3):68-76
20. Odike AI, Omokhodion SI, Akpede GO Findings on the Electrocardiogram of Children in Anaemic heart failure. *Arch.Clin.Res*.Vol.6, June 2018:55-63
21. Buttà C, Zappia L, Lattera G, Roberto M. Diagnostic and prognostic role of electrocardiogram in acute myocarditis: A comprehensive review. *Ann Noninvasive Electrocardiol*. 2020 May;25(3):e12726. doi: 10.1111/anecl.12726. Epub 2019 Nov 28. PMID: 31778001; PMCID: PMC7958927.
22. https://link.springer.com/chapter/10.1007/978-3-642-65681-1_28#citeas 11.11pm 06/07/24
23. Marinella MA. Electrocardiographic manifestations and differential diagnosis of acute pericarditis. *Am Fam Physician*. 1998 Feb 15;57(4):699-704. PMID: 9490993.
24. Hung Y, Lin WH, Lin CS, Cheng SM, Tsai TN, Yang SP, Lin WY. The Prognostic Role of QTc Interval in Acute Myocarditis. *Acta Cardiol Sin*. 2016 Mar;32(2):223-30. doi: 10.6515/acs20150226a. PMID: 27122953; PMCID: PMC4816921.
25. Carmelo B, Luca Z, Giulia L, Marco R. Diagnostic and prognostic role of electrocardiogram in acute myocarditis: a comprehensive review. *Annals of non invasive Electrocardiology*/vol 25, Issue 3 <https://doi.org/10.1111/anecl.12726>
26. (Gosselink AT, Van den Berg MP, Crijn HJ. Acute pericarditis presenting with sinus bradycardia: a case report. *Int J Cardiol*.1997 August 8;60(3)307-10. Doi: 10.1016/s0167-5273(97)00084-3. PMID:9261643)
27. (2009). Lassa Fever.In: *Clinical Guide to Bioweapons and Chemical agents*. Springer, London. https://doi.org/10.1007/978-1-84628-787-9_24
28. Micheal Gibson C. Lassa fever differential diagnosis <https://www.cdc.gov/> (2.43pm 17/7/23)
29. Ikeuchi K, Saito M, Yamamoto S, Nagai H, Adachi E. Relative Bradycardia in Patients with Mild-to-Moderate Coronavirus Disease, Japan. *Emerg Infect Dis*. 2020 Oct;26(10):2504-2506. doi: 10.3201/eid2610.202648. Epub 2020 Jul 1. PMID: 32610036; PMCID: PMC7510693.
30. Ribavirin: Bradycardia: 3 case reports. *Reactions Weekly*. 2016;1623(1):173. doi: 10.1007/s40278-016-22180-5. Epub 2016 Oct 15. PMCID: PMC7149120.
31. Burns ED, Buttner R . Intraventricular Conduction Delay (QRS widening <https://litfl.com/intraventricular-conduction-delay-qrs-widening/>)
32. Habara M, Fujieda H, Nakamura Y. Images in cardiology. Atrial myocarditis: a possible cause of idiopathic enlargement of bilateral atria. *Heart*. 2006 Jun;92(6):842. doi: 10.1136/hrt.2005.077420. PMID: 16698840; PMCID: PMC1860644.

33. Jackson LR 2nd, Ugowe F. Epidemiology and Outcomes Associated with PR Prolongation. Card Electrophysiol Clin. 2021 Dec;13(4):661-669. doi: 10.1016/j.ccep.2021.06.007. Epub 2021 Sep 23. PMID: 34689893; PMCID: PMC9918374.
34. Viskin S, Zelster D, Antzelevitch C. When u say "U Waves," what do u mean? Pacing Clin Electrophysiol. 2004 Feb;27(2):145-7. doi: 10.1111/j.1540-8159.2004.00403.x. PMID: 14764163; PMCID: PMC1513620.

