

ELECTROCARDIOGRAM AS A PREDICTIVE TOOL FOR THE SEVERITY AND CLINICAL COURSE OF PEDIATRIC DENGUE INFECTIONS

RIGIL MARIQUIETA FE P. SIAZON, MD
LEAH PATRICIA M. ARCEO-PLUCENA, MD

ABSTRACT

BACKGROUND: Dengue is a mosquito-borne viral disease that has been a global burden especially in the tropical regions. Cardiac involvement has been discussed in several studies. This is a pilot study to identify electrocardiogram abnormalities and correlate these with the severity of dengue illness.

OBJECTIVES: To evaluate the efficiency of electrocardiogram as a predictive tool for the severity and clinical course of pediatric dengue infections.

METHODS: This prospective cohort study was conducted at the Philippine Children's Medical Center from August to October 2017. A total of 325 dengue consults were seen at the pediatric emergency room during the study period. Of these, 66 pediatric patients fulfilled the inclusion criteria for this study. Serial pediatric electrocardiograms (ECG) were performed on days 1, 7, and 14 afebrile. The ECGs were interpreted according to rhythm, axis and duration of waveforms and intervals. These ECG interpretations were subsequently correlated to the patients' dengue severity and clinical course.

RESULTS: Rhythm abnormalities were found in 15 out of the 66 dengue patients for an overall incidence of 23%. All the rhythms were benign and self-limiting, including sinus bradycardia, tachycardia, and first-degree atrio-ventricular block. Majority of the dengue patients had sinus rhythm (42 of 66, 64%), and of these, 8 had heart rates at the lower limits of normal range for age (12%). 23 percent of abnormal rhythms were detected on day 1 of illness. All rhythm abnormalities resolved by day 14 of afebrile.

CONCLUSION: The series of ECG did not show clinically significant or life-threatening arrhythmias during the patients' dengue illness in this cohort. All arrhythmias were benign and self-limiting, regardless of dengue severity. The ECG did not correlate well with and cannot be utilized to predict the clinical course of the dengue illness.

RECOMMENDATIONS: A retrospective comparative study is recommended to determine predictability of dengue severity using ECG. A bigger cohort of dengue patients may detect significant arrhythmias not caught in this study.

KEYWORDS: Electrocardiogram, ECG, dengue with warning signs, severe dengue, bradycardia

INTRODUCTION

Dengue, a mosquito-borne viral disease, has been a global burden especially in the tropical regions. In the Philippines, it is already a year-round endemic disease with high morbidity and mortality among pediatric patients. It has been extensively studied with frequent updates on diagnosis, new case

classification, and management. However, parameters and diagnostic exams to predict which dengue patients will have complications and more severe disease have not been extensively elucidated. Routine laboratory examinations are requested such as complete blood count, NS1Ag, and dengue blot (IgM/IgG) to confirm dengue infection. However, there is no study that confirms the exact

correlation of dengue severity and a particular examination.

Cardiac complications arising from dengue infections are very rare. There are only a few studies, with its incidence ranging from as low as 6.7%, up to 36%.¹ These studies also describe dengue shock as being due to cardiovascular impairment and permeability caused by the viremia.

Dengue myocarditis is a relatively uncommon occurrence, with one study reporting it at 13.9%.² Moreover, this cardiac sequela has been found to be self-limiting, and in some cases subclinical, proven only by elevated cardiac enzymes that eventually resolve with the illness.

More commonly, dengue infections have been found to be associated with cardiac arrhythmias at various times during illness, most of which are benign. The underlying mechanisms for these electrical abnormalities can be due to altered autonomic tone, electrolyte and calcium derangements, or subclinical myocarditis. However, these electrical abnormalities in dengue have not been adequately studied.³ The electrocardiogram (ECG) is a readily available diagnostic tool in most tertiary hospitals. In this study, the electrocardiographic findings were documented on different days in the course of the dengue illness to determine if ECG can be used to predict the clinical course outcome and severity of dengue.

According to the World Health Organization (WHO) Global Strategy for Dengue Prevention and Control, dengue ranks as the most important mosquito-borne viral disease in the world in 2012, with a 30-fold increase in incidence over the past 5 decades.⁴ The literature review done by Bravo, et.al, showed that there is a consistent rise in the incidence of dengue disease from 2001-2011.⁵ A sharp increase was noticeable in the year 2010 as provided by both the Department of Health and the World Health Organization. Dengue disease was recorded highest among pediatric patients aged 5-14 years old with dengue-related deaths highest among children <9 years old.

In 2009, the WHO classified dengue cases as dengue with or without warning signs and severe dengue parallel to the 1997 classification of dengue fever, dengue hemorrhagic fever and dengue shock syndrome.⁶ Classifying dengue without warning signs requires febrile episodes accompanied by any two of non-specific symptoms such as nausea, vomiting, rash, aches, pain, leukopenia, or a positive tourniquet test. Warning signs include abdominal pain or tenderness, persistent vomiting, clinical fluid accumulation (i.e. ascites, pleural effusion), mucosal bleed, lethargy, restlessness, liver enlargement >2 cm, and a laboratory test showing increase in hematocrit concurrent with a rapid decrease in platelet count. Severe dengue is defined as having either severe plasma leakage leading to shock and/or fluid accumulation with respiratory distress, or severe bleeding as evaluated by a clinician, or severe organ involvement (i.e. elevated transaminases, impaired consciousness, heart failure or failure of other organs).

Cardiac involvement in dengue include function myocardial impairment, arrhythmias, and myocarditis that contribute to the overall severity of the hemodynamic compromise. Yacoub, et.al proposed viral and immune mechanisms involved in dengue compromising the cardiac and vascular system. Dengue virus (DENV) is taken up into macrophages resulting to T-cell activation and release of vasoactive and pro-inflammatory cytokines affecting capillary leak and possibly myocardial impairment. The interaction of NS1 and the glycocalyx layer of the vascular endothelium is thought to increase capillary permeability. The resulting plasma leakage can contribute to the cardiac dysfunction in the form of reduced preload, altered coronary microcirculation, and myocardial interstitial edema. Altered intracellular calcium homeostasis has also been demonstrated in dengue infected myotubes.⁷ Dengue myocarditis is diagnosed by elevated cardiac biomarkers with supplemental echocardiography of subclinical findings such as arrhythmias, and symptoms of dyspnea and chest pain.⁸ However, endomyocardial biopsy is still the gold standard in the diagnosis of myocarditis.

Yacoub, et. al., explained the reason behind cardiac dysfunction in dengue. The mechanism is shared by other studies done where high circulating proinflammatory cytokines cause myocardial depression as well as capillary permeability. Other potential mechanisms include altered intracellular calcium homeostasis and coronary hypoperfusion.⁹ Salgado, et.al. explained that the increased resting or diastolic calcium level in muscle cells during dengue infection may be responsible for the arrhythmias and altered contractile function of the myocardium.²

In a case control study done by Lateef, et.al, 3 out of 50 cases presented with bradycardia. Echocardiogram (2D-echo) was done and only 1 showed mitral valve prolapse with mild regurgitation.¹⁰

One study in Sri Lanka by Wichmann, et.al. showed that 25% of dengue patients presented with one or more elevated markers of myocardial injury, specifically myoglobin, creatine kinase MB (CK-MB), and troponin T.¹¹

In a literature review by Wiwanitkit, out of the thousand cases of dengue hemorrhagic fever (DHF) in Thailand, only 2 were reported as dengue myocarditis. Both were pediatric patients and presented with bradycardia and hypotension a day after recovering from DHF. ECG showed junctional rhythm.¹² A case report by Shah was an 11-year old boy who was tachycardic (110 beats/minute), hypotensive (85/50 mmHg), with prolonged capillary refill and bilateral basal crepitations. He was managed as a case of dengue. CK-MB was elevated, and 2d-echo showed left ventricular dilatation and systolic dysfunction with a fractional shortening of 22%. After 3 months, he was asymptomatic, and a repeat 2d-echo showed improved fractional shortening of 37%.¹³

In a cohort study by Satarasinghe, et.al, out of the 217 patients with dengue fever, 85% underwent echocardiography. Evidence of myocarditis was seen in 24% with an age range of 12-65 years old. All had relative bradycardia of 50-60 beats/minute.¹⁴

Gupta, et.al claimed a subclinical cardiac involvement in DHF. In 28 patients, 14% had bradycardia and 14% had 2d-echo finding of grade 1 diastolic dysfunction. In other cases, 2d-echo was normal but cardiac enzymes of CK-MB and troponin T were significantly increased, inferring a subclinical cardiac involvement.¹⁵

According to Yacoub, et.al, rhythm disturbances such as bradycardia were thought to occur primarily in the recovery phase. Heart rate is relatively lower at peak temperature in dengue patients compared to other illnesses with febrile episodes. ECG findings were reported to be transient and non-specific such as sinus bradycardia, AV block, T-wave, and ST segment abnormalities. In a 24-hour Holter monitoring study of 35 children in the recovery phase of dengue, 29% had ECG abnormalities, 27 with bradyarrhythmias (first and second degree heart block), atrial/ventricular ectopic beats, and tachyarrhythmias, including atrial fibrillation.⁷

The case series of Yantie, et.al, reported 10 patients with DHF who had ECG abnormalities, 3 patients showed sinus arrhythmias, 3 patients showed sinus bradycardia, 1 patient showed sinus tachycardia without fever, 2 patients showed a first-degree AV block and 1 patient showed a second-degree AV block Mobitz type I. Their abnormal ECG findings were mostly noted at days 6-7 of illness. Normal ECG was then documented at days 10-14 of illness.¹⁶ Wali, et.al, did a prospective study in Thailand. It reported that of 35 children, at least 24 hours after defervescence, 10 patients (29%) had abnormalities of rhythm, first-degree AV block, Mobitz type I second-degree AV block, atrial ectopics, and ventricular ectopics.¹⁷

La-Orkhun, et. al., used Holter monitoring to assess cardiac rhythm and rate among children (11.7 ± 2.3 years) with dengue infection. During the convalescent phase, 29% of patients had ECG abnormalities including sinus arrhythmias, first-degree and Mobitz type I second-degree AV block, and atrial and ventricular ectopic beats.¹⁸

Hussein, et. al., made a cross-sectional study among 17 diagnosed pediatric dengue patients who underwent electrocardiogram. Findings of P wave amplitude was getting shorter as the severity of dengue infection increased. While P wave duration increased slightly with increased severity of dengue infection. There was a significant increase in PR interval as the severity of dengue infection increased. The same was also true for ST and QTc wave.¹⁹ There are changes noted as severity of disease increased, however all values are still in the normal range.

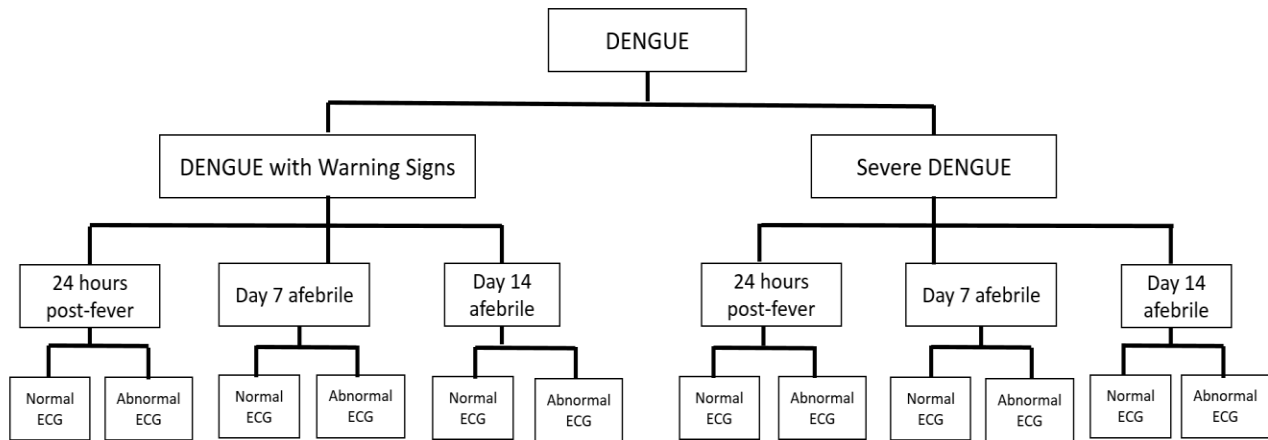
The cited journals provide data of dengue affecting the cardiovascular system. Moreover, there are abnormal ECG findings recorded specifically occurring when fever resolves. Whatever abnormal finding is recorded, this spontaneously resolves with null effect on the clinical course of the patient. Still, these ECG findings can also help predict the outcome of dengue.

METHODOLOGY

This was a prospective cohort study; included were children 5-18 years old; emergency room patients with a presumptive diagnosis of dengue; and confirmed diagnosis either with positive Dengue NS1Ag and/or Dengue IgM/ IgG. Excluded were patients with pre-existing congenital or acquired heart disease; patients with pre-existing cardiac arrhythmias of hemodynamic significance; patients with known hematologic and oncologic disorders; patients with co-existing infection aside from dengue; patients with congenital disorders and syndromes; and patients diagnosed with dengue but admitted day two or more of fever lysis.

Subjects were 66 consecutively admitted patients at the Philippine Children’s Medical Center (PCMC) from August to October 2017. They were classified as either with Warning Signs or Severe Dengue.

Description of the Study Procedure:



This prospective in-patient cohort study was conducted at the Philippine Children’s Medical Center for a period of three months from August to October 2017. All patients admitted at the Emergency Room, a total of 325, with a provisional diagnosis of dengue infection were screened for possible inclusion in the study and only those with serologic confirmation (NS1 antigen, Dengue blot) were included.

The patients were properly classified according to WHO classification of dengue severity: without warning signs (DWO), with warning signs (DWS), and severe dengue (DS). The baseline vital signs on admission were recorded at the ER, particularly temperature. Existing dengue management protocols were implemented, including laboratory tests and

fluid resuscitation, and left upon the discretion of ER team.

After securing consent, ECG were performed for each patient on the first day, seventh day and fourteenth day after fever lysis (D1, D7 and D14, respectively). If patients were discharged prior to day 7 afebrile, follow-up was scheduled on the date coinciding with the repeat ECG. The same is true for day 14 afebrile.

Each pediatric 15-Lead ECG was performed at the Cardiac Diagnostic Center, by either one of the ECG technicians using the Mortara ELI 250c ECG machine. The ECG was recorded and printed on standard ECG paper. The ECG was performed and recorded while the patient was asleep, or awake but calm and quiet. Crying and agitated patients had the procedure deferred until optimal conditions were achieved and was performed within the 24-hour period of the designated day. The ECG was read and interpreted by a pediatric cardiologist. These ECG readings were tabulated and analyzed for statistical significance according to dengue severity and day of illness. All ECGs were collated according to day of afebrile interpretation of rhythm, axis and duration of waveforms, and intervals were tabulated according to dengue severity.

The data gathered were recorded and processed prior to analysis using the MS Excel 2010. Control numbers were assigned to each item. Binary coding was employed for variables

of normal and abnormal results. The categorical variables were coded using numerical numbers. The scores were recorded in percentage. All variables were presented in frequency and percentage cross tabulations. The association of each variable to the type of dengue severity was assessed using Pearson Chi-Square Test for Independence or Adjusted Fisher's Exact Test. Significance level was set to 5%. Comparisons of means of ECG values between types of dengue severity were evaluated using Mann-Whitney test. Proportion, mean differences and associations were deemed significant if corresponding p-values of statistics did not exceed 0.05. SPSS version 20.0 was used to output all necessary results.

RESULTS

A total of 325 dengue consults were seen at the pediatric emergency room during the study period. Out of the 68 patients, 63 were diagnosed to have severe dengue (SD) while only 5 cases were registered to have dengue with warning signs (DWS). There were 2 cases who dropped out as early as day 1 afebrile due to lack of consent. Mean age for both groups was 10 years old, proving no significant difference in the mean and proportion of age distribution in between groups ($p=0.372 > 0.05$). More female patients were found in both DWS and DS groups. Despite disparity, no sufficient evidence was proven linking gender and severity of dengue ($p=0.413 > 0.05$). (Table 1)

Table 1. Demographic Profile of the Sample

Demographic Profile	Type of Dengue Severity						P-Value	
	Severe Dengue		Dengue with Warning Signs		Total			
	Frequency	Percent	Frequency	Percent	Frequency	Percent		
Age Group	5-8	1	20%	22	35%	23	34%	0.372
	9-12	2	40%	21	33%	23	34%	
	13-15	2	40%	9	14%	11	16%	
	16-18	0	0%	11	18%	11	16%	
	Total	5	100%	63	100%	68	100%	
<i>Age (Mean ± SD)</i>	<i>10.4 ± 3.21</i>		<i>10.6 ± 3.94</i>					

Table 1. (Continuation)

Demographic Profile		Type of Dengue Severity						P-Value
		Severe Dengue		Dengue with Warning Signs		Total		
		Frequency	Percent	Frequency	Percent	Frequency	Percent	
Sex	Male	2	40%	36	57%	38	56%	0.648
	Female	3	60%	27	43%	30	44%	
	Total	5	100%	63	100%	68	100%	
IgM	Yes	4	80%	39	62%	43	63%	0.645
	No	1	20%	24	38%	25	37%	
	Total	5	100%	63	100%	68	100%	
IgM/ IgG	Yes	4	80%	30	48%	34	50%	0.356
	No	1	20%	33	52%	34	50%	
	Total	5	100%	63	100%	68	100%	
Ns1Ag	Yes	1	20%	23	37%	24	35%	0.649
	No	4	80%	40	64%	44	65%	
	Total	5	100%	63	100%	68	100%	
IgG	Yes	4	80%	31	49%	35	52%	0.357
	No	1	20%	32	51%	33	49%	
	Total	5	100%	63	100%	68	100%	

Table 2 reveals that a normal ECG finding does not necessarily predict lesser dengue type among

patients; nor and abnormal ECG finding to severity of dengue.

Table 2. Association of General ECG Finding and Level of Dengue Severity at Day 1, 7, and 14 Afebrile

Period	ECG Finding	Severe Dengue		Dengue with Warning Signs		Total		P-Value
		Frequency	Percent	Frequency	Percent	Frequency	Percent	
Day 1	Normal	5	100%	46	75%	51	77%	0.15
	Abnormal	0	0%	15	25%	15	23%	
	Total	5	100%	61	100%	66	100%	
Day 7	Normal	1	50%	14	88%	15	83%	1
	Abnormal	1	50%	2	12%	3	17%	
	Total	2	100%	16	100%	18	100%	
Day 14	Normal	0	0%	8	89%	8	89%	NA
	Abnormal	0	0%	1	11%	1	11%	
	Total	0	0%	9	100%	9	100%	

Table 3 shows that all 5 cases of severe dengue and 46 diagnosed with dengue with

warning signs had sinus rhythm and sinus arrhythmia (77%) on Day 1. Among the 61

dengue with warning signs patients, the most prevalent abnormal ECG finding sinus bradycardia (n=6, 9%), generalized flattened T waves (n=3, 5%), and bradyarrhythmia (n=2, 3%). However, differences in proportions were

not proven to be statistically significant due to absence of cases in one group. Similarly, no sufficient evidence was proven to determine significant differences in the mean ECG values in between groups. (Table 3.1)

Table 3. Association of Findings from the Two Types of ECG and Type of Dengue Severity at Day 1 Afebrile

ECG Finding	Type of ECG Finding/Reading at Day 1	Type of Dengue Severity				Total	P-Value
		Severe Dengue		Dengue with Warning Signs			
		Frequency	Percent	Frequency	Percent		
Normal	Generalized flattened T waves	0	0%	0	0%	0	NA
	Prolonged QTc interval	0	0%	0	0%	0	
	Relative right axis deviation	0	0%	0	0%	0	
	Sinus arrhythmia	0	0%	9	20%	9	
	Sinus bradycardia	0	0%	0	0%	0	
	Sinus rhythm	5	100%	37	80%	42	
	Sinus tachycardia	0	0%	0	0%	0	
	Total	5	100%	46	100%	51	
Abnormal	Generalized flattened T waves	0	0%	3	20%	3	NA
	Prolonged QTc interval	0	0%	1	7%	1	
	Relative right axis deviation	0	0%	1	7%	1	
	Sinus arrhythmia	0	0%	0	0%	0	
	Sinus bradyarrhythmia	0	0%	2	13%	2	
	Sinus bradycardia	0	0%	6	40%	6	
	Sinus rhythm	0	0%	0	0%	0	
	Sinus tachycardia	0	0%	2	13%	2	
Total	0	0%	15	100%	15		

Table 3.1 Comparisons of Means between Severe and Dengue with Warning Signs at Day 1 Afebrile

	Type of Dengue Severity	N	Mean	Std. Deviation	P-Value
PRDay1	Severe Dengue	5	0.14	0.02	0.226
	Dengue with Warning signs	61	0.15	0.02	
RateDay1	Severe Dengue	5	79.40	14.76	0.538
	Dengue with Warning signs	60	74.77	13.96	
QRSDurationday1	Severe Dengue	5	0.08	0.03	0.887
	Dengue with Warning signs	61	0.08	0.01	
QTADurationDay1	Severe Dengue	5	0.31	0.15	0.436
	Dengue with Warning signs	61	0.37	0.03	
QTCDay1	Severe Dengue	5	0.42	0.02	0.085
	Dengue with Warning signs	61	0.40	0.02	

Note: PR interval = seconds, mean±SD = Mean±Standard Deviation; QRS duration = seconds, mean ± standard deviation; rate = beats per minutes

Table 4 shows that on Day 7 afebrile, there were two patients with severe dengue was 2, one having a normal sinus rhythm and the other with first degree AV block. On the other hand, cases of patients with dengue with warning signs were reduced from 61 to 16. Majority (n=10, 71%)

had normal ECG findings. No p-value was calculated due to absence of cases in one group. Similarly, no sufficient evidence was gathered to determine significant differences in the mean ECG values between groups. (Table 4.1)

Table 4. Association of Findings from the Two Types of ECG and Type of Dengue Severity at Day 7 Afebrile

ECG Finding	Type of ECG Finding/Reading at Day 7	Type of Dengue Severity				Total	P-Value
		Severe Dengue		Dengue with Warning Signs			
		Frequency	Percent	Frequency	Percent		
Normal	Sinus rhythm	1	100%	10	71%	10	NA
	Sinus arrhythmia	0	0	4	29%	4	
	Total	1	100%	14	100%	14	
Abnormal	Prolonged QTc interval	0	0%	1	50%	1	NA
	Sinus arrhythmia	0	0%	0	0	0	
	Sinus tachycardia	0	0%	1	50%	1	
	First degree AV block	1	100%	0	0%	0	
	Total	1	100%	2	100%	2	

Table 4.1 Comparisons of Means between Severe and Dengue with Warning Signs at Day 7 Afebrile

	Type of Dengue Severity	N	Mean	Std. Deviation	P-Value
PRDay7	Severe Dengue	2	0.17	0.06	0.72
	Dengue with Warning signs	16	0.14	0.02	
RateDay7	Severe Dengue	2	86.50	10.61	0.44
	Dengue with Warning signs	16	80.94	8.35	
QRSDay7	Severe Dengue	2	0.07	0.01	0.60
	Dengue with Warning signs	16	0.07	0.01	
QTaDay7	Severe Dengue	2	0.35	0.04	0.29
	Dengue with Warning signs	16	0.37	0.03	
QTCDay7	Severe Dengue	2	0.41	0.01	1.00
	Dengue with Warning signs	16	0.41	0.03	

Note: PR interval = seconds, mean±SD = Mean±Standard Deviation; QRS duration = seconds, mean ± standard deviation; rate = beats per minute

On Day 14 afebrile, no more cases of severe dengue patients were recorded and only 9 patients were still diagnosed to have dengue with warning signs. Only 1 out of the 9

remaining had an abnormal ECG finding (incomplete right bundle branch block) while all the 89% (or 8 patients) had normal sinus rhythm (Table 5).

Table 5. Type of Dengue Severity per ECG Findings at Day 14 Afebrile

	Type of Dengue	
	Dengue with Warning signs	
	Frequency	Percent
Sinus rhythm (Normal)	8	89%
Incomplete right bundle branch block (Abnormal)	1	11%
Total	9	100%

DISCUSSION

This study shows that there are ECG findings that deviate from normal in patients with dengue. Despite the absence of abnormal clinical findings on cardiac examination such as rate, rhythm or murmurs, subclinical ECG findings were noted. There were also varying duration of ECG intervals in relation to the day of afebrile that can help predict cardiac involvement. The results do not point to an age predilection of dengue severity among pediatric patients. In terms of gender, there was no predilection as to the severity despite the predominance of female subjects with dengue with warning signs and severe dengue.

The findings in this study are consistent with the findings by Yacoub, et.al., with rhythm disturbances occurring primarily during the recovery phase and were observed to be transient and non-specific. This study similarly showed heart rates of low-normal levels during the recovery phase. This is also consistent with the study done in Thailand by Wali, et. al. where 24-hour post-defervescence findings were rhythm abnormalities, ectopies and AV blocks. This is also comparable to the study made by Yantie, et. al., where abnormal ECG findings were noted during days 6-7 illness, however the day of fever lysis was not indicated. The pathophysiology of the abnormal rhythm, as well as rate, is explained by proinflammatory cytokines causing myocardial depression, capillary permeability, and increase in resting calcium level. The mean heart rate in DWS was 74.77 ± 13.96 bpm in this study, comprising 12% of DWS cases with bradycardia during the recovery phase.

During day 7 afebrile, a decrease in the number of abnormal ECG findings was noted. The patients failed to follow-up for a repeat ECG. The reasons for failure to comply can be due to low follow-up rate in the outpatient or low positive reinforcement to encourage follow-up. First degree AV block in severe dengue, and prolonged QTc interval and sinus arrhythmia in dengue with warning signs were significant findings. The case with first degree AV block had severe dengue with a prior ECG of sinus rhythm. The other case of first degree AV block was a patient with dengue with warning signs who had an initial finding of sinus bradycardia. All these rhythms were interpreted as normal pediatric variants. This is in consistent with the findings of Yantie, et. al., where normal ECG findings seen during days 10-14 of illness.

During day 14 afebrile, there was a decrease in the number of patients who followed-up for the third and last ECG. All the remaining cases were dengue with warning signs. Among the 9 cases, one had an incomplete right bundle branch block. The previous reading of the said case during the days 1 and 7 afebrile was sinus rhythm. The 2 cases with first degree AV block during the day 7 afebrile failed to do the repeat ECG on day 14 afebrile, hence whether such findings resolved was not established.

The rhythm disturbances during day 1 afebrile were found to have spontaneously resolved as the days progressed. This is like Yantie, et. al. where normal ECG findings were recorded as the day of illness progressed and patients were already afebrile.

The difference in PR interval between the DWS and DS groups was not statistically significant. The PR interval mean (range) for

DWS was 0.15 ± 0.02 ($0.13 - 0.17$) second and compared to 0.14 ± 0.02 ($0.12 - 0.16$) second for the DS patients. Despite within normal levels, there are certain changes in ECG values notably more in DWS that might explain cardiac involvement. The difference in QRS duration was likewise not statistically significant between the two groups, in DS was 0.08 ± 0.03 (0.05 to 0.1) second and for DWS was 0.08 ± 0.01 ($0.07 - 0.09$) second. The recorded QTc interval for all cases were all within normal values. During days 7 and 14 afebrile, all the recorded heart rates were normal. The QRS duration was also normal.

CONCLUSION AND RECOMMENDATIONS

ECG can be used to assess the cardiac function of dengue infection. Rhythm findings included bradycardia, bradyarrhythmia, and sinus tachycardia which were observed consistently during the first day of recovery phase. Most of these findings were benign and self-limiting. The ECG values (i.e. PR and QRS duration), despite within normal levels provide changes in the verified values that might predict cardiac involvement and severity in dengue infection. As the days of afebrile progressed, the heart rate and PR-QRS intervals improved to normal values. The ECG did not correlate well with and cannot be utilized to predict the clinical course of the dengue illness.

This study only observed the type of ECG finding as a predictor to dengue severity. Failure to correlate the above variables was affected by a very limited sample size causing no patterns yet on the records. Whether ECG can be used to predict dengue severity needs further study to link the said variables.

Further research on the predictability of ECG to dengue severity is urged. A retrospective comparative study among dengue patients who underwent ECG and an active-control (standard diagnosis) is recommended first to determine predictability of the level of dengue severity using ECG as a tool to set a grounding evidence for succeeding protocols with higher statistical power and accuracy. After

preliminary evidence is established, a prospective study may be utilized using randomized parallel study design, i.e., comparing two groups with the primary aim of investigating whether ECG could be used as a possible alternate diagnostic tool from standard predictor of dengue severity. ROC Analysis may be utilized to determine accuracy rate of the alternative method. Sample size may be computed by referring to the results of the retrospective study.

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