AN ULTRASOUND SCORING SYSTEM TO PREDICT OF DEVELOPING SHOCK FOR DENGUE HEMORRHAGIC FEVER

Dr RANG NGOC NGUYEN

Abstract:
The aim of this study is to develop a scoring system for predicting of developing shock in patients with DHF by using sonography to detect free fluid in peritoneal and pleural cavities.
Methods:This prospective study included 224 patients with DHF (124 with shock and 120 without shock), the means age for 2 groups was 7,8 years old. The ultrasound examination was performed on day 4 or day 5-6 of the illness and hematocrit determination was done simultaneously.
Based on the frequency and the depth of fluid collections appearing in DHF patients with shock and non-shock, we developed the scoring system that predicts patients' risks of developing shock in DHF. Afterward, we assessed the validity of our scoring system by plotting a receiver operating characteristic (ROC) curve, compared with ROC curve for scoring system developed by Setiawan et al. (14) and with ROC curve for hematocrit.
Results: The suggested ultrasound scoring system was presented as follows:

Regions		*Points*
GBWT ≥ 5mm	*No*	*0*
	Yes	*1*
Morison's pouch	*No fluid*	*0*
	Minimal fluid	*1*
	*Significant **	*2*
Subphrenic space	*No fluid*	*0*
	Fluid	*1*
Pouch of Douglas' cul-de-sac	*No fluid*	*0*
	Minimal fluid	*1*
	*Significant **	*2*
Paracolic gutters	*No fluid*	*0*
	Fluid	*1*
Floating bowel loops	*Fluid*	*2*
Right pleural effusion	*No fluid*	*0*
	Minimal fluid	*1*
	*Significant **	*2*
Left pleural effusion	*No fluid*	*0*
	Fluid	*1*
	Ultrasound score is sum of all points	*(0-12)*

** The depth of fluid is equal or more than 5mm*

The mean score in shock patients was 7.7 (SD 2.0), while the mean score in non-shock patients was 2.4 (SD 2.9); clearly the distributions are very different.
This score discriminated well between patients who develop shock and those who did not. A cut-off value of 5 had a sensitivity of 90%, specificity of 80% for predicting of

developing shock. The area under the ROC curve of our ultrasound scoring system (0.90 [95% CI 0.86-0.94]) was higher than that of for hematocrit (0.81 95% CI [0.75-0.86]). Conclusion: Sonography provides a fast, portable, and noninvasive method for detecting fluid collections in peritoneal and pleural cavities. The use of ultrasound scoring system is of value for predicting of developing shock. A ultrasound score of 5 had a sensitivity of 90%, specificity of 80% for predicting of developing shock in DHF patients.

Introduction

Dengue hemorrhagic fever (DHF) is caused by 4 serotypes of dengue virus, mainly transmitted by *Aedes aegypti*. DHF is a significant public health problem in most of the countries in the tropical areas of the South-East Asia and Western Pacific Regions (1). In Vietnam, there were 1,518,808 cases of DHF resulting 14,133 deaths reported from 1956 to 1995 (2).

Two main pathophysiological changes occur in DHF or dengue shock syndrome (DSS) are a disorder in hemostasis and an increased vascular permeability. The latter gives to loss plasma from the vascular compartment and leaks to the interstitial and serous spaces. Hematocrit is a simple indicator to estimate the degree of the plasma leakage. Nevertheless, hematocrit does not rise in patients with anemia or hemorrhage.

Sonography has been used since 1990s to identify peritoneal fluid and pleural effusion in blunt abdominal trauma with high sensitivity and specificity (3-12). In recent years, sonography has been used to detect fluid collections in peritoneum and pleura in patients with DHF (13-16). Moreover, detecting of free fluid on ultrasonography can predict the severity of the disease (15).

The aim of this study is to develop a scoring system for predicting of developing shock in DHF patients by using ultrasonography to detect free fluid in peritoneal and pleural cavities.

Materials and methods:

This prospective study was performed at Pediatric ward of An Giang general hospital, Vietnam, between 1995 and 2001. All patients from 0 to 14 years old, suspected with DHF or DSS were included. Diagnosis of DHF and its grades based on clinical criteria set by World Health Organization (1) as followings:

- Grade I and grade II are non-shock DHF. In grade I the only hemorrhagic manifestation is a positive tourniquet test, while in grade II those is spontaneous bleeding.
- Grade III and grade IV are cases of DHF with shock. In grade III, signs of shock including cold clammy skin, restlessness, rapid and weak pulse, narrow pulse pressure (20mmHg or less) or hypotension. Grade IV cases are those with profound shock with undetectable pulse and/or blood pressure.

Confirmatory diagnosis of DHF based on Mac-Elisa test to detect IgM of dengue virus. The ultrasound (US) examination was performed from day 4 to day 6 of the diseases with a Toshiba Capasee machine using a 3.5 MHz sector transducer probe. In all patients, the standard sonographic examination included longitudinal and transverse images of the right upper quadrant, including the right subphrenic space, the left upper quadrant, the pelvis, both lower quadrants. Besides measuring the thickening of gallbladder wall, US was utilized to identify the presence of free fluid in seven areas: the pleural space bilaterally,

the right subphrenic space, the Morison recess, paracolic gutters bilaterally, and the pelvis (cul-de-sac of Douglas).
Each area, the measurement of the fluid pocket is obtained at the site of greatest depth. The depth of fluid collections is calculated in millimeter on ultrasonography. The quantity of fluid in each area is defined as small if the depth is lower than 5mm and as large if the depth is equal or more than 5mm. The gallbladder's wall thickening (GBWT) is defined as GBWT of 5mm or greater.
Hematocrit was done simultaneously for each patient with ultrasound examination.
Based on the frequency and dimension of fluid collections appearing in DHF patients with shock and non-shock in the present study and the scoring system developed by Setiawan *et al.* (14), we developed the new scoring system that predicts patients' risks of developing shock in DHF. The quantity of fluid in each area was graded as none (0 point), minimal (1 point) or significant (2 points), except the subphrenic space, paracolic gutters, and left pleural cavity where fluid accumulated in small volume was rated as none (0 point) or minimal (1 point).
Afterward, we assessed the validity of the scoring system by plotting a receiver operating characteristic (ROC) curve, compared with ROC curve for scoring system developed by Setiawan *et al.* (14) and with ROC curve for hematocrit.

Statistical analysis:
Data analysis and statistics were performed by using the SPSS statistical package version 10.0.1 for Windows 1998. The chi-square testor Fisher's exact test were used to compare categorical variables. Analysis of variance was used to compare between 2 groups. To assess the discrimination, the area under the ROC and its 95% confidence interval was used. A value of $P < .05$ was considered statistically significant.

Results:

There were 244 sonograms (124 shock and 120 non-shock patients) obtained during the 5-year study period. The sex ratios in shock cases were 43% boys and 57% girls and non-shock cases were 51% boys and 49% girls. The mean ages of shock and non-shock cases were nearly identical, with 7.8 years (SD 3.5-3.7).
The percentage of fluid collections in each area was presented in table 1. There are clear statistically different between shock and non-shock cases for all areas.
Table 1. The percentage of GBWT, pleural and peritoneal fluid in DHF patients with and without shock

	Non-shock (n=120)	Shock (n=124)	P value
GBWT ≥ 5mm	51 (42.5%)	122 (98.4%)	0.001
Morison's pouch	34 (28.3%)	112 (90.3%)	0.001
Subphrenic space	26 (21.7%)	91 (73.4%)	0.001
Douglas' cul-de-sac	49 (40.8%)	103 (83.1%)	0.001
Paracolic gutters	14 (11.7%)	56(45.2%)	0.001
Floating bowel loops	7 (5.8%)	53 (42.7%)	0.001
Right pleural effusion	32 (26.7%)	94 (75.8%)	0.001
Left pleural effusion	3 (2.5%)	25 (20.2%)	0.001

Depending on the percentage of fluid in 7 areas, the US scoring system for predicting of developing shock was developed and shown in table 2

Table 2. The suggested ultrasound scoring system

		Points
GBWT ≥ 5mm	No	0
	Yes	1
Morison's pouch	No fluid	0
	Minimal fluid	1
	Significant *	2
Subphrenic space	No fluid	0
	Fluid	1
Pouch of Douglas' cul-de-sac	No fluid	0
	Minimal fluid	1
	Significant *	2
Paracolic gutters	No fluid	0
	Fluid	1
Floating bowel loops	Fluid	2
Right pleural effusion	No fluid	0
	Minimal fluid	1
	Significant *	2
Left pleural effusion	No fluid	0
	Fluid	1
	Ultrasound score is sum of all points	(0-12)

* The depth of fluid is equal or more than 5mm

The mean score in patients with shock was 7.7 (SD 2.0), while the mean score in non-shock patients was 2.4 (SD 2.9); clearly the distributions are very different.

Table 3. The sensitivity and specificity of the scoring system depend on the threshold of score chosen.

Score	Sensitivity	Specificity
1	98%	59%
2	98%	65%
3	91%	77%
4	95%	75%
5	90%	80%
6	73%	85%
7	53%	92%
8	34%	96%
9	18%	99%
10	11%	99%
11	1%	100%

The area under the ROC curve of our ultrasound scoring system was 0.90 (95% CI 0.86-0.94). which was higher than that of ultrasound score developed by Setiawan *et al.* (0.85 [95% CI 0.80-0.90]) and also higher than the area under the ROC curve for hematocrit (0.81 95% CI [0.75-0.86]) (figure1).

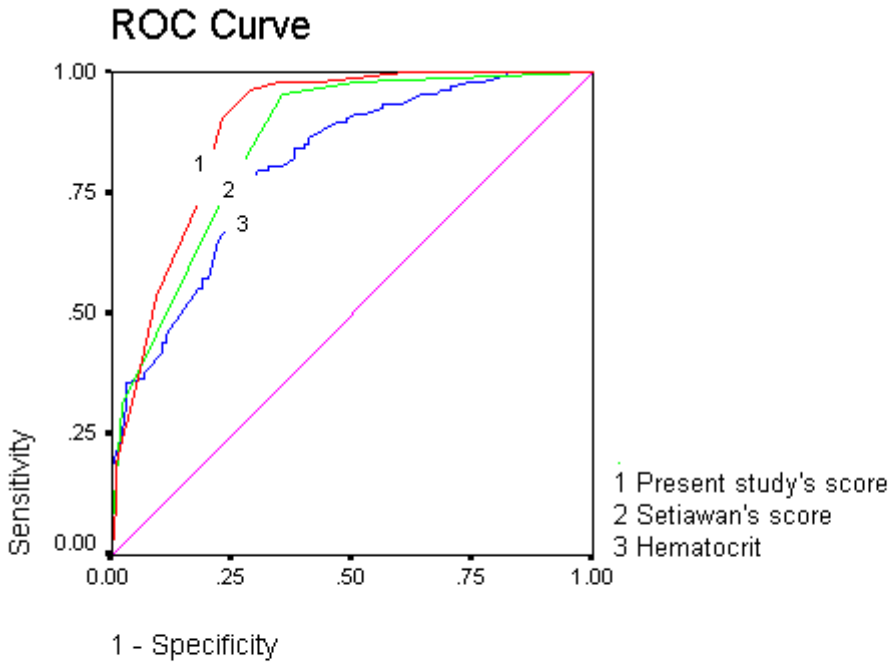

Figure1. ROC curve for our ultrasound score, Setiawan's score and ROC curve for hematocrit.

Discussion

In this report, we present a simple score scheme for predicting the risk of developing hypovolemic shock in patients with DHF. This scoring system contained the information on previous ultrasound score in patients with DHF reported by Setiawan *et al.* (table 4).

Table 4. Ultrasound scoring developed by Setiawan *et al.* (14)

	Score
1.Pleural effusion	
Fluid is seen in the right pleural cavity	2
Fluid is seen in the right and left pleural cavities	4
2. Ascites	
Fluid is seen only in the hepatic region	2
Fluid is seen in the perihepatic and Perivesical region	4
Increase fluid create the sign of free/ floating bowel loops	6

In our study, some areas with high frequency of fluid accumulations depicted on US in DHF with shock should introduce in the scoring system. The first location is Morison's pouch. US is very sensitive to detect the fluid collection as small as 40ml of free fluid at this recess (17). In our study, fluid collection at Morison's pouch was seen in 90.3% in DHF patients with shock and 28.3% in those without shock ($p<0.001$). The second location is the right subphrenic space which was seen on ultrasonography as an anechoic crescent between the diaphragm and the liver (figure 2). The fluid collection at the subphrenic space

was seen in 73.4% in shock patients and 21.7% in non-shock patients ($p < 0.001$). The third locations are paracolic gutters where free fluid is accumulated in the early stage of the disease when peritoneal fluid is minimal. This accumulation was depicted on US in 45.2% of patients with shock and in 11.7% of those without shock ($p<0.001$).

Figure 2. Fluid collection in the right subphrenic space (black arrow)

Additionally, thickening of the gallbladder wall is due to edema and this is considered as an indirect sign to indicate the peritoneal fluid (18). According to Setiawan *et al.* (19), a GBWT of ≥ 5mm was used as a criterion for identifying DHF patients at a high risk of developing hypovolemic shock with 93.8% sensitivity and 91.7% specificity. In this study, GBWT accounted for 98.4% in DHF patients with shock and 42.5% in those without shock ($p<0.001$).

Using this scoring system for DHF patients with and without shock in our series, we found that the mean score of patients with shock (7.7 SD 2.0) is significant higher than that of patients without shock (2.4 SD 2.9) ($p< 0.001$). This score discriminated well between patients who develop shock and those who did not. A cut-off value of 5 had a sensitivity of 90%, specificity of 80% for predicting of developing shock.

In DHF, the hemoconcentration indicates the leakage of plasma into extravascular spaces and hematocrit determination is useful to give diagnosis and predicting the pre-shock and shock phases of the illness (20). Thus, we assessed the validity of our ultrasound scoring system by plotting a ROC curve and compared with ROC curve for ultrasound score devised by Setiawan *et al.* and ROC curve for hematocrit. The area under the ROC curve of our ultrasound score was 0.90 (95% CI 0.85-0.93), which was marginally higher than the area under the ROC for Setiawan's ultrasound score (0.85 [95% CI 0.80-0.90]) and for hematocrit (0.81 95% CI [0.75-0.86]). As a result, our ultrasound scoring system is as accurate as hematocrit determinations for predicting the risk of developing shock in patients with DHF in clinical practice.

In conclusion, sonography provides a fast, portable, and noninvasive method for assessment of DHF patients. The use of ultrasound in DHF not only offers the detection of fluid collections in peritoneum and pleura but also allows for fluid quantification through using a scoring system. The DHF patients with a ultrasound score of 5 had a risk of developing shock with 90% sensitivity and 80% specificity.

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