Sri Lanka Journal of Medicine **SLJM**

Original Research

Citation: Fernando N[1], Fernando K[2,3], Gallage T[1] and Dayanath BKTP[2], et al. 2023. Knowledge of the High-Sensitivity Cardiac Troponin Assay among Medical Officers in Gampaha District, Sri Lanka. Sri Lanka Journal of Medicine, pp 26-37.
DOI: https://doi.org/10.4038/sljm.v32i2.440

Knowledge of the High-Sensitivity Cardiac Troponin Assay Among Medical Officers in Gampaha District, Sri Lanka

N Fernando[1], K Fernando[2,3], T Gallage[1], BKTP Dayanath[2], ST De Silva[1,4]

[1]University Medical Unit, Colombo North Teaching Hospital, Ragama, Sri Lanka
[2]Department of Chemical Pathology, Colombo North Teaching Hospital, Ragama, Sri Lanka
[3]Department of Biochemistry and Clinical Chemistry, Faculty of Medicine, University of Kelaniya, Sri Lanka
[4]Department of Medicine, Faculty of Medicine, University of Kelaniya, Sri Lanka

Correspondence:
K Fernando
E mail: kavindyam@kln.ac.lk

ABSTRACT

Introduction: The high-sensitivity cardiac troponin (hs-cTn) assay is a crucial diagnostic test that is obligatory in the triage of patients presenting with chest pain. It is essential for medical officers to have adequate knowledge regarding the procedures for testing and the interpretation of test outcomes to deliver optimal healthcare for patients. It has been observed that medical officers are lacking in awareness regarding this testing method, resulting in a greater likelihood of errors in testing and interpretation. This study aims to evaluate the level of understanding among medical officers regarding the hs-cTn assay in relation to the most recent European Society of Cardiology guideline released in 2020.

Methodology: We conducted a cross-sectional study at two government hospitals in Gampaha District in June 2022. A self-administered e-questionnaire was used to assess knowledge regarding hs-cTn. Knowledge was measured by calculating a cumulative score for the answers to a questionnaire and categorised into good or poor knowledge. A score less than 60% was categorized as poor and vice versa. Descriptive statistics were used to summarize the data.

Results: Of the 227 medical officers, only 14.5% (n=33) had good knowledge of the analytical component while 41.9% (n=95) had good knowledge on the clinical component. A score ≥60% on the analytical component knowledge was significantly associated with designation being a senior registrar or consultant (p<0.001), postgraduate enrolment (p<0.001), participation in continuous professional development programmes (p<0.001), and employment in a teaching hospital (p=0.025), but not with age (p=0.066) or private practice (p=0.118). Clinical component knowledge score ≥60% was significantly associated with age between 25 and 35 years (p=0.006), designation being a consultant (p<0.001), postgraduate enrolment (p<0.001), participation in continuous professional development programs (p<0.001), and employment in a teaching hospital(p=0.001) but not with doing private practice (p=0.170).

Conclusions: In Sri Lanka, medical officers' general knowledge on the hs-cTn assay seems lacking. There is a need for continuous training to improve knowledge on hs-cTn testing among medical officers.

Keywords: Troponin-I, Hight-Sensitivity Cardiac Troponin, Delta Check, Acute Coronary Syndrome

Received: 2023-09-16 **Accepted revised version: 2023-12-06** **Published: 2023-12-31**

INTRODUCTION

Myocardial infarction (MI) is a significant contributor to mortality rates worldwide, and there is a growing prevalence of this condition in younger populations (1). The timely identification of MI during its critical early phase, sometimes referred to as the "golden period," is of utmost importance in order to promptly commence treatment and to mitigate myocardial damage. Cardiac biomarkers play a crucial role in the early identification of cardiovascular diseases. At present, assessment of patients for triage purposes generally relies on the measurement of these cardiac biomarkers (2).

Cardiac troponin is the biomarker most frequently utilised in modern medical practice. The level of troponin I in the bloodstream frequently demonstrates an elevation within 4 to 6 hours of an event (2), peaking at 12 hours, and subsequently reverting to baseline during 3 to 10-14 days. In contrast, troponin T demonstrates sustained elevation for a duration of 12 to 48 hours, after which it gradually returns to its baseline within ten days (Figure 1) (3).

In the past troponin I detection was performed after a time interval of 4 hours following chest pain, in order to overcome the issue of false negativity. However, in 2010, experts in the field of chemical pathology made an important step forward by successfully adopting high-sensitivity cardiac troponin (hs-cTn) assays. This achievement was the result of a series of research efforts aimed at improving the detection limits of these assays (4).

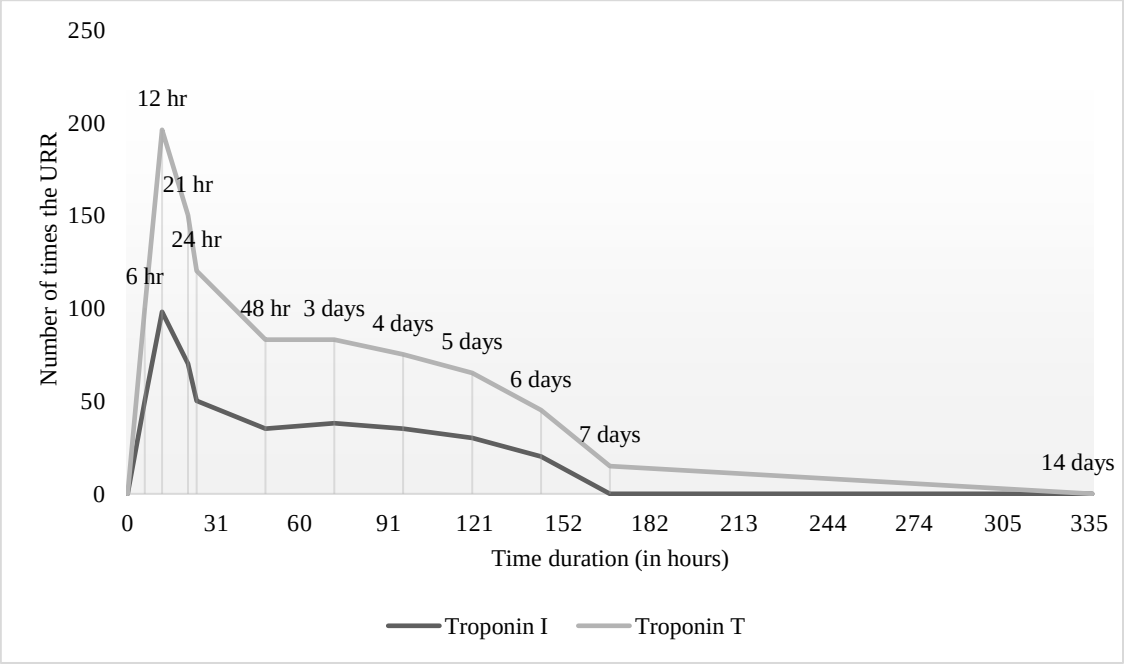

Figure 1: Variation of troponin level in serum following a myocardial injury (modified and republished with permission. Data from (2))

URR- upper reference range

High-sensitivity cardiac troponin (hs-cTn) analysis has emerged as a notable breakthrough in the field of cardiac markers, fundamentally transforming our comprehension on acute coronary syndrome (ACS). The prompt evaluation and management of ACS has substantially reduced mortality rates and alleviated the overall impact of ACS on cardiac morbidity (5). The increased sensitivity of this

diagnostic tool has improved diagnosis rates among individuals presenting with symptoms suggestive of ACS, improving overall quality of patient care (6).

Early detection of any medical condition improves effectiveness of its management and overall quality of healthcare (7). Additionally, accurate exclusion of the absence of a condition offers several benefits, including early patient discharge and reduction of unwarranted medical interventions. Despite the assay being used for over a decade, medical practitioners continue to have difficulties interpreting test results, and erroneous practices remain.

The most recent guideline including the latest updates on hs-cTn assay available during the research period was the 2020 European Society of Cardiology (ESC) Guidelines for the Management of Acute Coronary Syndromes in Patients Presenting Without Persistent ST-Segment Elevation (6). This guideline offers a comprehensive evaluation of the hs-cTn assay. It is crucial that persons who are suspected of experiencing ACS undergo the assessment of a biomarker that reflects damage to heart muscle cells, with a preference for hs-cTn (6,7). High-sensitive assays are preferred over conventional assays because they offer superior diagnostic accuracy at a low cost (8–11).

A thorough understanding of hs-cTn measurement and interpretation facilitates a faster assessment of MI triage in patients who seek medical attention immediately after experiencing chest pain (8–11). This capability facilitates both the inclusion and exclusion of MI as a potential diagnosis and demonstrates similar diagnostic accuracy in the early detection of MI (12,13). Currently, automated platforms perform cardiac troponin testing at various governmental and non-governmental hospitals in Sri Lanka.

Since it has been observed that many medical officers struggle to interpret troponin, I test results this study was designed to assess knowledge regarding the hs-cTn assay among medical officers. The study also aimed to look at associations between the level of knowledge and sociodemographic and educational factors. This is the first study from Sri Lanka evaluating the level of understanding of the hs-cTn assay among medical professionals, to the best of our knowledge.

MATERIALS AND METHODS

Subjects

This was a cross-sectional study conducted from June to August 2022. Participants were selected from two government hospitals, namely Colombo North Teaching Hospital and District General Hospital, Negombo, located in the Gampaha district of the Western Province in Sri Lanka. The study sample was selected from medical officers permanently employed by the Ministry of Health and attached to various medical units. The inclusion criteria were all medical professionals including house officers, senior house officers, registrars, senior registrars, and consultants of medical units. Medical officers working in laboratory settings, including those working in the fields of biochemistry, microbiology, and haematology, and medical officers assigned to surgical units were excluded.

METHODOLOGY

A questionnaire derived from the "2020 ESC Guidelines for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-segment Elevation" was used to gather data (6). The questionnaire was used to obtain information on sociodemographic characteristics of participants and their level of knowledge and awareness of the hs-cTn test in clinical and analytical contexts.

Data was collected using an electronic version of the self-administered questionnaire. Study details were provided to participants by electronic mail. Participants were informed that their voluntary completion and submission of the questionnaire would serve as consent to participate in the study. When participants did not respond to the original email, reminders with a link to the questionnaire were emailed to them on two additional occasions.

The questionnaire consisted of a combination of close-ended and multiple-choice questions. It comprised of 18 questions, where 11 questions looked at the practical implementation of hs-cTn in

the clinical environment and 7 questions looked at analytical and laboratory concepts related to hs-cTn assay (Supplemental data 1). In order to minimize potential bias from respondents referring to the ESC guideline (2020) prior to answering questions, they were requested to fill out the questionnaire on the spot. Each accurate response was allocated a score of one point, while incorrect answers, responses indicating "do not know", and unanswered questions were given a score of zero. All individual points were added up to calculate a total score. The cumulative score was converted to a numerical scale spanning from 0 to 100. A satisfactory level of understanding regarding the hs-cTn assay was set at a score of 60% or more, since this level of knowledge is necessary to deliver best quality care to patients with ACS.

Statistical analysis

The data was summarised using the Statistical Package for the Social Sciences (SPSS 20). Categorical data were analysed using percentages and frequencies, whereas continuous variables were assessed through the calculations of means, medians, and standard deviations. The statistical significance of relationships between categorical variables was assessed using the Pearson's Chi-squared ($\chi 2$) test. Statistical tests were deemed to be statistically significant if the associated p-value was less than 0.05. Row percentages were calculated to determine the group with the highest performance based on age, designation, and years of service.

Ethical approval for the study was obtained from the Ethics Review Committee of the Faculty of Medicine, University of Kelaniya, Sri Lanka (Ref No: P/27/05/2022). Study participation was purely voluntary. The participants had the autonomy to withdraw from the study at any point during the data collection process.

RESULTS

Of a total sample of 300 medical officers, a response rate of 76% was achieved with 227 participants returning full questionnaires. Table 1 provides an overview of the professional and demographic characteristics of the medical officers who participated in the study.

Table 1: Demographic characteristics of the study population (n= 227)

Variable	Frequency (%) (*n*= 227)
Gender	
Female	138 (60.8)
Age	
25 – 35	163 (71.8)
36 – 45	40 (17.6)
More than 45	24 (10.5)
Workstation	
Colombo North Teaching Hospital	139 (61.2)
District General Hospital Negombo	88 (38.8)
Designation	
House Officer	22 (9.7)
Senior House Officer/ Medical Officer	135 (59.5)
Registrar	52 (22.9)
Senior Registrar	11 (4.8)
Consultant	7 (3.1)
Service years	
Less than 1	29 (12.8)
1 to 5	113 (49.8)
5 to 12	56 (24.7)
More than 12	29 (12.8)
Engagement in postgraduate studies	70 (30.8)
Participation in CPD Programs related to hs-cTn assays	28 (12.3)
Has read latest ECS guideline update on hs-cTn assay	59 (26)
Engagement in part time private practice	43 (18.9)

Abbreviations: CPD = Continuous Professional Development, ESC = European Society of Cardiology, hs-cTn = high sensitivity cardiac troponin

Medical officers' knowledge regarding hs-cTn assay interpretation.

Supplemental data 2(Supplemental data 2) shows the frequency and distribution of participant responses. Separate assessments of clinical component and laboratory-based analytical component were conducted, and a score of at least

60% was considered indicative of a high-level knowledge.

Median cumulative score for the entire questionnaire was 46% (range: 11 to 95). The mean (SD) score was 49.6% ± 19.2. In the separate analysis of clinical component knowledge, the median score was 52% (range: 12 to 96) and the mean (SD) score was 54% ± 20.1. The laboratory-based analytic component had a median score of 33% (range: 8 to 100), and a mean (SD) score was 40.3% ± 22.4.

Knowledge on hs-cTn assay among medical officers was extremely poor in both clinical and analytical aspects. Based on the criterion used for adequate knowledge, 56/227 (24.7%) participants had adequate knowledge of hs-cTn assay, in accordance with ESC 2020 recommendations. None of the participants obtained 100 marks as the final score. However, assessment of the two categories revealed that only 95/227 (41.9%) and 33/227 (14.5%) participants had adequate knowledge of the hs-cTn assay in the clinical and analytical aspects, respectively.

Figures 2 and 3 depict the frequency of participants who were aware of substances that interfere with the hs-cTn assay and diseases other than ACS for which hs-cTn assay can become positive, respectively.

Clinical component: Analysis of individual responses indicated that a significant proportion of medical officers lacked awareness regarding the updated recommendations on the timing of sample collection for the hs-cTn assay. Specifically, correct response percentages were found to be 24.2% for the initial sample collection and 28.2% for the second sample collection, as shown in Supplemental data 2. Moreover, a significant majority of medical officers demonstrated limited familiarity with certain medical conditions such as severe anaemia (30%), severe hypertension (33%), stroke (35%), and hypovolemic shock (41%) (Figure 3). Most doctors were not aware of the definition of unstable angina (UA), with 67.4% incorrectly stating that hs-cTn value can be elevated in UA. Due to the increased sensitivity of the hs-cTn test, however, a large number of patients fall into the category of non-ST elevation myocardial infarction, thereby decreasing the frequency of UA diagnoses.

Laboratory-based analytical component: The area in which the participant demonstrates the least awareness is the concept of "delta check", which refers to a range of values for the difference between two consecutively measured results observed in two samples from the same patient. When exceeded, it considers the measured result as doubtful (14). Over two-thirds of the participants showed a lack of familiarity with the term "delta check" and were not aware that it is dependent on the assay technique (Supplemental Table 1). Results of questions on interfering substances/conditions for the hs-cTn assay revealed that medical officers lack knowledge on that aspect too (Figure 2).

Relationship between medical officer characteristics and knowledge of hs-cTn assay

Associations to a score equal to or above 60% were studied using the chi-squared test. The level of significance was set at $p<0.05$. A significant association was found between knowledge on hs-cTn in clinical aspects and working in a tertiary care hospital ($p=0.001$), designation ($p <0.001$), engaging in postgraduate studies ($p<0.001$), participation in Continuing Professional Development (CPD) programs ($p<0.001$), and reading ESC guidelines ($p<0.001$).

Knowledge of the analytical aspects of hs-cTn assay was significantly associated with age ($p = 0.006$), working in a tertiary care hospital ($p = 0.025$), designation ($p<0.001$), service years ($p=0.002$), engaging in postgraduate studies ($p < 0.001$) and participation in CPD programs ($p < 0.001$). However, there was no significant association between clinical knowledge of hs-cTn and age ($p = 0.066$) and service years ($p = 0.074$). Further analytical knowledge of hs-cTn and reading the most recent ESC guidelines revisions ($p = 0.298$) were not statistically significant. Neither clinical and analytical components did not show any association with engagement in part-time private practice. (Table 2)

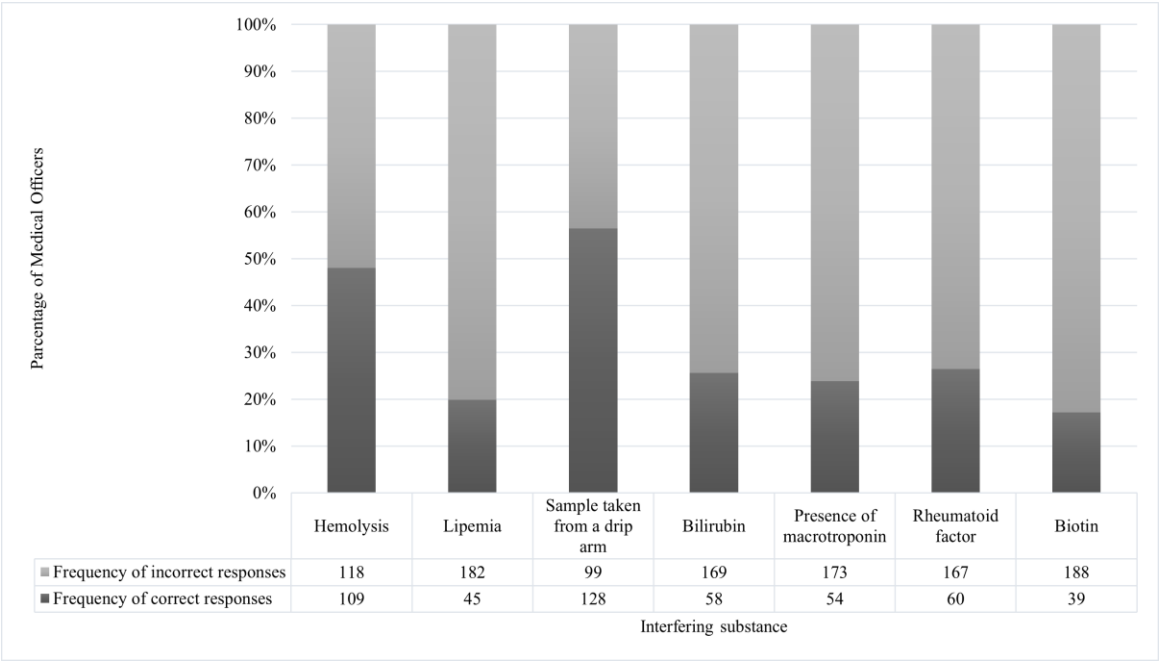

Figure 1: Frequency distribution regarding awareness of interfering substances and other conditions that can interfere with hs-cTn assay.

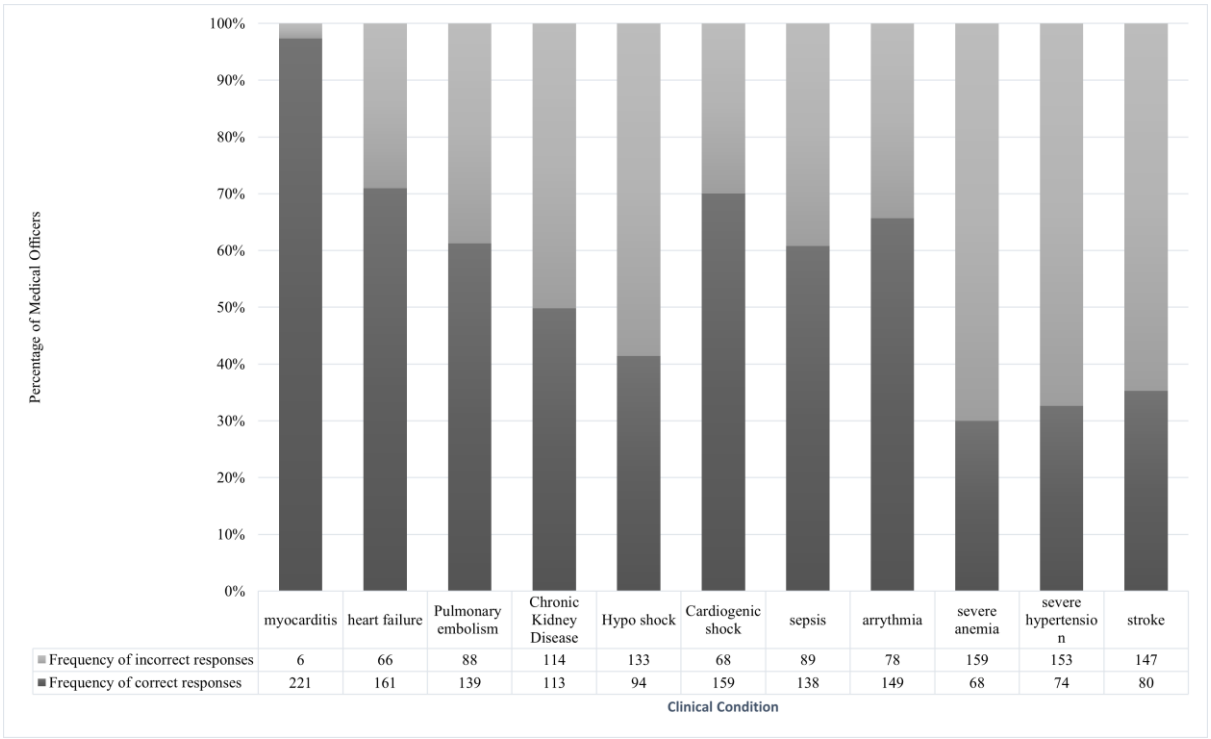

Figure 2: Frequency distribution regarding knowledge of other clinical conditions that can provide positive results in hs-cTn assay.

Table 2: Association between characteristics of medical officers and knowledge regarding clinical and analytical aspects of hs-cTn (n=227)

		Clinical component			Analytical component		
		Poor knowledge	Good knowledge	*p-value **	Poor knowledge	Good knowledge	*p-value **
Age group							
	25-35	87	76	*0.066*	132	31	*0.006*
	36-45	28	12		40	0	
	> 45	17	7		22	2	
Workstation							
	CNTH	69	70	*0.001*	113	26	*0.025*
	DGH Negombo	63	25		81	7	
Designation							
	House officers	15	7	*<0.001*	16	6	*<0.001*
	MO/SHO	99	36		132	3	
	Registrar	18	34		31	21	
	Senior Registrar	0	11		11	0	
	Consultants	0	7		4	4	
Service years							
	Less than 1	22	7	*0.074*	23	6	*0.002*
	1 to 5	59	54		89	24	
	6 to 12	31	25		56	0	
	More than 12	20	9		26	3	
Engagement in Postgraduate qualifications							
	Yes	18	52	*< 0.001*	46	24	*< 0.001*
Participation in CPD Programs related to hs-cTn assays							
	Yes	5	23	*<0.001*	18	10	*<0.001*
Reading latest ESC guideline update on hs-cTn							
	Yes	14	45	*<0.001*	48	11	*<0.298*
Engagement in part time private practice							
	Yes	29	14	*0.170*	40	3	*0.118*

** Chi square*

Abbreviations: CNTH = Colombo North Teaching Hospital, CPD = continuous professional development, DGH = district general hospital, ESC = European Society of Cardiology, hs-cTn = high sensitivity cardiac troponin, MO = medical officer, SHO = senior house officer

Table 3: Row percentage of correct responses of medical officers age, designation and service years with knowledge regarding clinical and analytical components of hs-cTn (n=227)

		Age			Statistical significance (*p* value *)
		25-35	35-45	More than 45	
Row percentage	Clinical component	46.6%	55.0%	29.1%	0.066
	Analytical component	19.0%	0.0%	8.3%	0.006

		Designation					
		HO	SHO/MO	Registrar	Senior Registrar	Consultant	
	Clinical component	31.8%	26.7%	65.4%	100%	100%	<0.001
	Analytical component	27.2%	2.2%	39.7%	0.00%	100%	<0.001
		Service years					
		< 1 year	1 to 5 years		6 – 12 years	> 12 years	
	Clinical component	24.1%	47.7%		44.6%	31.0%	0.074
	Analytical component	20.7%	21.2%		0.00%	10.3%	0.002

** Chi square*

Abbreviations: HO = house officer, MO = medical officer, SHO = senior house officer

Table 3 displays the row percentages used to determine which group has the greatest influence on the analytical and clinical components of the hs-cTn assay. Among consultants, medical officers with a service year between 1 and 5 years and medical officers between the ages of 25 and 35 were found to have the greatest knowledge of the analytical component. The respondents with service years between 1 and 5 years is also represented in the category of the age group between 25 to 35.

DISCUSSION

Only one fourth of the medical doctors in this study had adequate knowledge on hs-cTn assessment. Medical officers' understanding of the analytical component of hs-cTn was subpar compared to the clinical component. Nearly all (98.2%) medical officers were aware of the type of troponin that should be ordered in a patient presenting with chest pain. The majority of participating medical officers (89.9%) were unaware of what a "delta check" is.

There are numerous assay techniques available for assessing hs-cTn. The threshold for diagnosis of myocardial injury is the assay-specific 99th percentile upper reference limit (14). These assay-specific reference values are defined in the ESC guidelines. Depending on the assay used by them, laboratories provide different reference values. Therefore, it is essential to test the second sample using the same method as the first, as only this will enable consideration and interpretation of the delta check. Most medical officers were unaware of this fact which can greatly influence clinical judgment during patient treatment, with only 32.6% of the study sample knowing that the second sample should be analysed in the same laboratory.

The hs-cTn assay is an immunoassay technique (15), and many substances can interfere with its interpretation. Haemolysis (16), lipaemia (17), (18), haemodilution (19), and presence of macrotropnin (20), bilirubin (21), rheumatoid factor (22) and biotin (16) are known to interfere with the hs-cTn assay-interfering substances. Knowledge of medical officers was abysmal with regard to these interfering substances, with less than 25% providing the correct response (Figure 2). Since these interfering substances produce false positive results knowledge of such interfering substances is essential in interpreting assay results.

In addition to ACS, several cardiac diseases can lead to damage of cardiomyocytes and result in increased levels of cardiac troponin in the

bloodstream. These include tachyarrhythmia (23,24), heart failure (25), hypertensive emergencies (26), critical illness (27), myocarditis (28,29), Takotsubo syndrome (30), and valvular heart disease (31). In cases when cardiac troponin levels are elevated, it is important to consider aortic dissection (32) and pulmonary embolism (33) as potential differential diagnoses. Hypertensive heart disease is another important contributor to the elevation of cardiac troponin, which clinicians should keep in mind (34). The findings of this study indicate that a majority of medical officers were aware of other cardiac pathologies that can elevate cardiac troponin. However, their understanding of non-cardiac factors contributing to elevated cardiac troponin was lacking (Figure 3).

The study found that medical officers' knowledge of the analytical aspects of the hs-cTn assay did not correlate with their reading of the most recent updates to the ESC guideline. One possible explanation for this may be that medical officers tend to prioritise their attention to clinically relevant amendments when reading guideline updates. There is a tendency to neglect analytical aspects due to the perception that such concepts are either irrelevant or difficult to comprehend. However, a positive relationship was observed between the clinical component and reading the most recent guidelines. This is one of the key areas that should be addressed when medical updates are organized, emphasising the importance of having an in-depth knowledge of analytical concepts.

Limitations

The study was limited to two hospitals in the Gampaha district and used convenient sampling to select study participants. Medical officers who work in the rural provinces of Sri Lanka were not sampled. The somewhat low response rate to the study was another limitation. The response rate of 76% may not provide a comprehensive representation of the performance of the individuals who did not respond, and the findings might be skewed as a result. The questionnaire was prepared based on a single guideline, but there are several other guidelines that provide recommendations on hs-cTn testing. Nevertheless, due to the cross-sectional nature of the study, the results indicate that having adequate and up-to-date knowledge can be predicted based on certain variables, including service duration, prior participation in CPD programmes, and the designation of the participant.

To date, no research has been done to assess medical officers' knowledge on hs-cTn assay in Sri Lanka. Research conducted to evaluate knowledge and adherence of Sri Lankan medical professionals to dyslipidaemia guidelines found that medical officers enrolled in postgraduate training and working in tertiary care institutions had greater knowledge, which is consistent with the findings of the study. The study also found that part-time private practice also increased knowledge, contrary to the findings of our study (35).

Limited research has been conducted in Sri Lanka to evaluate knowledge and practices of medical officers in various medical disciplines. A study conducted to assess knowledge related to medical ethics showed that postgraduate trainees had higher knowledge compared to other grades (36). Research conducted to compare knowledge of medical emergency management revealed a negative correlation between years of work experience and knowledge acquisition, contradicting the findings of the current study (37).

Implications for future research and clinical practice

Based on the results of this study, knowledge and practices among newly recruited junior doctors in hs-cTn assay and ordering need to be enhanced. This should be conducted early in their career as medical officers. It is necessary to arrange CPDs when new guidelines are published or updated to minimise unnecessary interventions and to improve the quality of care and service provided to patients. More research should be conducted in future to evaluate adequacy of knowledge in these domains. Studies are also needed to identify barriers to adaptation of new updates, and such barriers should be promptly addressed to improve overall management of ACS.

CONCLUSIONS AND RECOMMENDATIONS

This study found that medical officers in the Gampaha District of Sri Lanka lacked knowledge regarding hs-cTn testing. The clinical aspect of knowledge on hs-cTn was better with involvement in postgraduate training, attending CPD programs, working in tertiary care hospitals, and referring to the latest guideline updates, while the analytical component was better with young age (between 23-35), involvement in postgraduate training, attending CPD programs, working in tertiary care hospitals, and service between 1 to 5 years. The high-sensitivity cardiac troponin assay is an advanced analytical method, and it is crucial for practitioners utilising this technique to maintain up-to-date knowledge in order to maximise its utility.

The hs-cTn assay is a sophisticated technique and the knowledge of those who use it should be updated to get the most out of it. When planning academic sessions special attention should be paid to the analytical assessment of the test as it can significantly influence the outcomes and overall quality of the test. If these domains can be improved, there will be a direct improvement in the skills of medical officers which will indirectly benefit the government economically by reducing unnecessary interventions, test repetition, and length of hospital stay.

Author declaration

Acknowledgements:
We gratefully acknowledge the doctors of the Colombo North Teaching Hospital and District General Hospital, Negombo for participating in this study.

Authors' contributions:
Study concept and design, acquisition of data, analysis and interpretation of data, statistical analysis, drafting of the manuscript: N.F. and K.F.; Study supervision: B.D. and S.D.S.

Conflicts of interest:
The authors declare that there is no financial or non-financial conflict of interest.

Ethics statement:
Ethical clearance was granted by the ERC of Faculty of Medicine, University of Kelaniya, Sri Lanka (Ref No: P/27/05/2022). The participants were informed of the study by a letter and submitting the questionnaire was taken as consent for participation. The researchers had no access to any personal data of the participants.

Statement on data availability:
All data generated and analysed in the study are included in this publication and the supplementary files.

REFERENCES

1. Sinha SK, Krishna V, Thakur R, Kumar A, Mishra V, Jha MJ, et al. Acute myocardial infarction in very young adults: A clinical presentation, risk factors, hospital outcome index, and their angiographic characteristics in North India-AMIYA Study. ARYA Atheroscler. 2017 Mar;13(2):79–87.
2. Jacob R, Khan M. Cardiac Biomarkers: What Is and What Can Be. Indian J Cardiovasc Dis women WINCARS. 2018 Dec;3(4):240–4.
3. Garg P, Morris P, Fazlanie AL, Vijayan S, Dancso B, Dastidar AG, et al. Cardiac biomarkers of acute coronary syndrome: from history to high-sensitivity cardiac troponin. Intern Emerg Med [Internet]. 2017;12(2):147–55. Available from: https://doi.org/10.1007/s11739-017-1612-1
4. Gaggin HK, Januzzi JL. Cardiac Biomarkers and Heart Failure [Internet]. American Collage of Cardiology. 2015. Available from: https://www.acc.org/%2Flatest-in-cardiology%2Farticles%2F2015%2F02%2F09%2F13%2F00%2Fcardiac-biomarkers-and-heart-failure
5. Fanta K, Daba FB, Tegene E, Melaku T, Fekadu G, Chelkeba L. Management quality indicators and in-hospital mortality among acute coronary syndrome patients admitted to tertiary hospitals in Ethiopia: prospective observational study. BMC Emerg Med [Internet]. 2021;21(1):41. Available from: https://doi.org/10.1186/s12873-021-00433-3
6. Collet J-P, Thiele H, Barbato E, Barthélémy O, Bauersachs J, Bhatt DL, et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: The Task Force for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J [Internet]. 2021 Apr 7;42(14):1289–367. Available from: https://doi.org/10.1093/eurheartj/ehaa575
7. Guedeney P, Collet J-P. Diagnosis and Management of Acute Coronary Syndrome: What is New and Why? Insight From the 2020 European Society of Cardiology Guidelines. J Clin Med. 2020 Oct;9(11).
8. Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, et al. Fourth Universal Definition of

Myocardial Infarction (2018). Circulation. 2018 Nov;138(20):e618–51.
9. Reichlin T, Twerenbold R, Reiter M, Steuer S, Bassetti S, Balmelli C, et al. Introduction of high-sensitivity troponin assays: impact on myocardial infarction incidence and prognosis. Am J Med. 2012 Dec;125(12):1205-1213.e1.
10. Mueller C, Giannitsis E, Möckel M, Huber K, Mair J, Plebani M, et al. Rapid rule out of acute myocardial infarction: novel biomarker-based strategies. Eur Hear journal Acute Cardiovasc care. 2017 Apr;6(3):218–22.
11. Chapman AR, Fujisawa T, Lee KK, Andrews JP, Anand A, Sandeman D, et al. Novel high-sensitivity cardiac troponin I assay in patients with suspected acute coronary syndrome. Heart. 2019 Apr;105(8):616–22.
12. Boeddinghaus J, Nestelberger T, Koechlin L, Wussler D, Lopez-Ayala P, Walter JE, et al. Early Diagnosis of Myocardial Infarction With Point-of-Care High-Sensitivity Cardiac Troponin I. J Am Coll Cardiol. 2020 Mar;75(10):1111–24.
13. Boeddinghaus J, Twerenbold R, Nestelberger T, Badertscher P, Wildi K, Puelacher C, et al. Clinical Validation of a Novel High-Sensitivity Cardiac Troponin I Assay for Early Diagnosis of Acute Myocardial Infarction. Clin Chem. 2018 Sep;64(9):1347–60.
14. Castro-Castro MJ, Dot-Bach D, Candás-Estébanez B, Cano-Corres R, Fuentes-Arderiu X. Estimation of alert and change limits and its application in the plausibility control. Accredit Qual Assur [Internet]. 2011;16(12):643–7. Available from: https://doi.org/10.1007/s00769-011-0837-3
15. Jarolim P. High sensitivity cardiac troponin assays in the clinical laboratories. Clin Chem Lab Med. 2015 Apr;53(5):635–52.
16. Harley K, Bissonnette S, Inzitari R, Schulz K, Apple FS, Kavsak PA, et al. Independent and combined effects of biotin and hemolysis on high-sensitivity cardiac troponin assays. Clin Chem Lab Med. 2021 Jul;59(8):1431–43.
17. Farrell C-JL, Carter AC. Serum indices: managing assay interference. Ann Clin Biochem [Internet]. 2016 May 3;53(5):527–38. Available from: https://doi.org/10.1177/0004563216643557
18. Krasowski MD. Educational Case: Hemolysis and Lipemia Interference With Laboratory Testing. Acad Pathol. 2019;6:2374289519888754.
19. Lagneau F, Beyne P, Letteron P, Laperche T, Marty J. Fluid therapy directly interferes with immunoassay for cardiac troponin I. Intensive Care Med. 1999 Jun;25(6):625–7.
20. Lam L, Heron C, Aspin L, Ha L, Kyle C V. Change in troponin concentrations in patients with macrotroponin: An in vitro mixing study. Clin Biochem [Internet]. 2020;85:43–8. Available from: https://www.sciencedirect.com/science/article/pii/S0009912020308201
21. Dasgupta A, Wells A, Biddle DA. Negative interference of bilirubin and hemoglobin in the MEIA troponin I assay but not in the MEIA CK‐MB assay. J Clin Lab Anal [Internet]. 2001 Mar 1;15(2):76–80. Available from: https://doi.org/10.1002/jcla.5
22. Bayoumy S, Martiskainen I, Heikkilä T, Rautanen C, Hedberg P, Hyytiä H, et al. Sensitive and quantitative detection of cardiac troponin I with upconverting nanoparticle lateral flow test with minimized interference. Sci Rep. 2021 Sep;11(1):18698.
23. Liu Z, Cui L, Wang Y, Guo Y. Cardiac troponin I and ventricular arrhythmia in patients with chronic heart failure. Eur J Clin Invest. 2006 Jul;36(7):466–72.
24. Sharain K, Vasile VC, Jaffe AS. Does cardiac rhythm monitoring in patients with elevated troponin levels lead to changes in management? Eur Hear journal Acute Cardiovasc care. 2017 Sep;6(6):545–52.
25. Potluri S, Ventura HO, Mulumudi M, Mehra MR. Cardiac troponin levels in heart failure. Cardiol Rev. 2004;12(1):21–5.
26. Tehrani DM, Fan W, Nambi V, Gardin J, Hirsch CH, Amsterdam E, et al. Trends in Blood Pressure and High-Sensitivity Cardiac Troponin-T With Cardiovascular Disease: The Cardiovascular Health Study. Am J Hypertens. 2019 Sep;32(10):1013–20.
27. Lim W, Cook DJ, Griffith LE, Crowther MA, Devereaux PJ. Elevated Cardiac Troponin Levels in Critically Ill Patients: Prevalence, Incidence, and Outcomes. Am J Crit Care [Internet]. 2006 May 1;15(3):280–8. Available from: https://doi.org/10.4037/ajcc2006.15.3.280
28. Smith SC, Ladenson JH, Mason JW, Jaffe AS. Elevations of Cardiac Troponin I Associated With Myocarditis. Circulation [Internet]. 1997 Jan 7;95(1):163–8. Available from: https://doi.org/10.1161/01.CIR.95.1.163
29. Lauer B, Niederau C, Kühl U, Schannwell M, Pauschinger M, Strauer BE, et al. Cardiac troponin T in patients with clinically suspected myocarditis. J Am Coll Cardiol. 1997 Nov;30(5):1354–9.
30. Chadha S, Lodha A, Shetty V, Sadiq A, Hollander G, Frankel R, et al. Troponins in Tako-tsubo Cardiomyopathy. Hear Lung Circ [Internet]. 2013 Sep 1;22(9):775–7. Available from: https://doi.org/10.1016/j.hlc.2012.12.010
31. McCarthy CP, Donnellan E, Phelan D, Griffin BP, Enriquez-Sarano M, McEvoy JW. High sensitivity troponin and valvular heart disease. Trends Cardiovasc Med. 2017 Jul;27(5):326–33.
32. Bonnefoy E, Godon P, Kirkorian G, Chabaud S, Touboul P. Significance of serum troponin I elevation in patients with acute aortic dissection of the ascending aorta. Acta Cardiol. 2005 Apr;60(2):165–70.
33. Becattini C, Vedovati MC, Agnelli G. Prognostic value of troponins in acute pulmonary embolism: a meta-analysis. Circulation. 2007 Jul;116(4):427–33.
34. Eggers KM, Jernberg T, Lindahl B. Cardiac Troponin Elevation in Patients Without a Specific Diagnosis. J Am Coll Cardiol. 2019 Jan;73(1):1–9.
35. Ansy A, Angunawala A, Anushika E, Ariyasena S, Aryachandra S, Fernando K, et al. Knowledge and adherence to National Institute of Clinical Excellence 2020, dyslipidaemia management guidelines and its associations among medical officers in Gampaha district, Sri Lanka: a descriptive study. Asian J Intern Med. 2023;
36. Ranasinghe AWIP, Fernando B, Sumathipala A,

Gunathunga W. Medical ethics: knowledge, attitude and practice among doctors in three teaching hospitals in Sri Lanka. BMC Med Ethics. 2020 Aug;21(1):69.

37. Ralapanawa DMPUK, Jayawickreme KP, Ekanayake EMM, Kumarasiri PVR. A study on the knowledge and attitudes on advanced life support among medical students and medical officers in a tertiary care hospital in Sri Lanka. BMC Res Notes [Internet]. 2016;9(1):462. Available from: https://doi.org/10.1186/s13104-016-2270-5