THE QUEST TO IMPROVE MANAGEMENT OF PATIENTS WITH CHEST PAIN IN THE EMERGENCY DEPARTMENT

Implementing the European Society of Cardiology (ESC) 0-hour/1-hour algorithm with high sensitivity cardiac troponin T in Institut Jantung Negara

Executive summary

As the leading tertiary cardiac centre in Malaysia, the emergency department of Institut Jantung Negara (IJN) receives large numbers of patients with undifferentiated chest pain. Limitations in the management of these cases contribute to long waiting times for patients, which in turn, contributes to overcrowding in the department. A multidisciplinary collaboration between the emergency and laboratory departments was initiated to examine existing processes and pathways in the management of patients with undifferentiated chest pain. The aim was to introduce an improved pathway that would accurately identify and safely discharge patients at low risk of acute coronary syndrome (ACS). The 0-hour/1-hour algorithm using high-sensitive cardiac troponin T (hs-cTnT) was implemented as per the recommendations of the 2020 European Society of Cardiology guidelines. Following implementation, the average length of stay in the emergency department was reduced by 25 minutes for 90% of patients, as a result of the 33% reduction in turnaround time for hs-cTnT testing. There was no increase in repeat visits within 24 hours post discharge among patients with low-risk chest pain, which supported the evidence that the hs-cTnT 0-hour/1-hour algorithm allows for the safe and rapid discharge of patients presenting with low-risk chest pain.

Undifferentiated chest pain: the challenges of management in emergency departments

Chest pain accounts for 5-10% of patients presenting symptoms at emergency departments (EDs).[1] At IJN's ED, however, chest pain accounts for up to 50% of cases, with a high proportion being IJN patients with established cardiac disease. Managing patients with undifferentiated chest pain requires several hours based on conventional methods, which poses a challenge for a busy ED. Complicating the process are patients with atypical presentations, unreliable history, variable risk factors and on occasion, inconclusive electrocardiogram (ECG) results.

The challenges of chest pain management have implications for patient outcomes. Patients in IJN's ED faced an average length of stay of 6 hours, contributing to overcrowding and its associated problems, which includes delayed care. There is also the risk of inadvertently discharging patients with undiagnosed ACS.

The objectives of IJN's Chest Pain Patient Process Improvement Project

The IJN's Chest Pain Patient Process Improvement Project was a multidisciplinary collaboration between the institute's ED and laboratory department that aimed to enhance the safety, efficiency, and effectiveness of chest pain management in the ED, specifically the identification and safe discharge of low-risk patients.

Key steps in IJN's Chest Pain Patient Process Improvement Project

The Process Improvement Project involved several important steps:

a. Mapping the existing patient journey in IJN's ED, with a focus on process steps, waiting times and roles of key personnel (**Table 1** provides a template for the process).
b. Mapping the sample flow from the ED to the laboratory and back.
c. Assessing adherence to guideline recommendations or validated clinical protocols, and identifying problematic processes and contributing causes within the existing patient journey and sample flow. This involved assessment of:
   i. The clinical pathway, which encompasses diagnostics/treatment protocols, risk assessment scores and flow/process charts.
   ii. The information flow, which references data sources and systems such as patient records, forms, test results and reports.
d. Developing actionable solutions and implementing them in a stepwise process. Parameters that were likely to be impacted by these solutions, e.g., waiting times and the number of patients in the waiting area, were assessed before and after implementation of these solutions to assess their effectiveness.

Table 1. Patient presenting with chest pain in the ED: A patient journey map template.

Pre-arrival process steps*	Define the steps taken by the paramedics.
Primary triage process steps*	Define the steps taken during the primary triage and measure the average duration/waiting time for each step. Identify key personnel† and their roles.
Secondary triage process steps*	Define the steps taken during the secondary triage and measure the average duration/waiting time for each step. Identify key personnel† and their roles.
Diagnosis*	Define the steps taken and investigations performed to arrive at a definitive diagnosis and measure the average duration/waiting time for each step. Identify key personnel† and their roles.
Next steps	Define the next steps i.e., to treat, admit or discharge from the ED, and measure the average duration/waiting time for each step. Identify key personnel† and their roles.

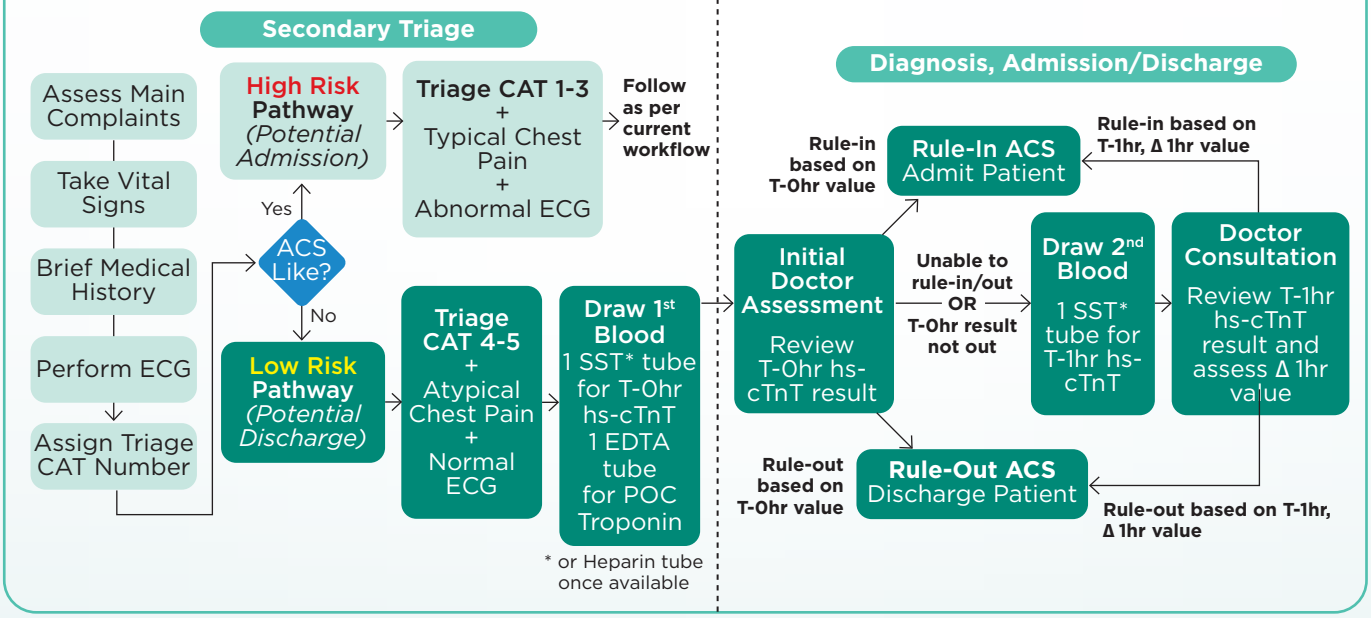
* Differentiate the process steps as diagnostics steps, intervention (treat/admit) steps, decision-making steps
† May include, but not restricted to, the Admissions Clerk, Cardiologist, Health Attendant, Medical Assistant, Medical Officer and Staff Nurse.

Ruling out ACS: a key gap identified

The Chest Pain Patient Process Improvement Project found that the lack of diagnostic tools to quickly and safely rule out myocardial infarction (MI) contributed to delays in discharging patients with non-cardiac / low risk atypical chest pain.

In response to this finding, the project group developed a new workflow that would accurately identify and safely discharge low-risk patients (***Figure 1***).

Figure 1. A revamped chest pain management pathway (incorporating the hs-cTnT rapid algorithm) for IJN's emergency department



ACS, acute coronary syndrome; CAT, category; ECG, electrocardiogram/ electrocardiography; EDTA, ethylenediaminetetraacetic acid; hs-cTnT, high-sensitive cardiac troponin T; POC, point of care; SST, serum separating tube

The revamped flow required an ECG for all chest pain patients during triage. High-risk patients with ongoing chest pain or ECG findings suggestive of ACS would be prioritized for treatment and admission. Patients who do not fall in this category would have their blood taken at triage and again 1 hour later. These patients would be provided an information sheet (***Figure 2***) that alerts them to the new process and empowers them to initiate the repeat blood sampling. The doctor would then assess the patient, ECG and blood results. The decision to admit or discharge the patient would be made based on the clinical presentation and high-sensitive troponin T algorithm (***Figure 1***).

Figure 2. Patient information sheet regarding the standard investigations for undifferentiated chest pain in IJN's emergency department

Dear Patient,

As you have had chest pain, we would like to ensure that you are managed safely based on an established protocol.

We will be performing the following investigations:

1. Electrocardiogram (ECG) to look for major heart attack. This test may be repeated.
2. Blood test (troponin) to look for minor heart attack/heart muscle injury. Blood will be taken 2 times, when you arrive and 1 hour later at _____AM/PM. Kindly alert us when it is time for your second blood test as the time specified.

Thank you.

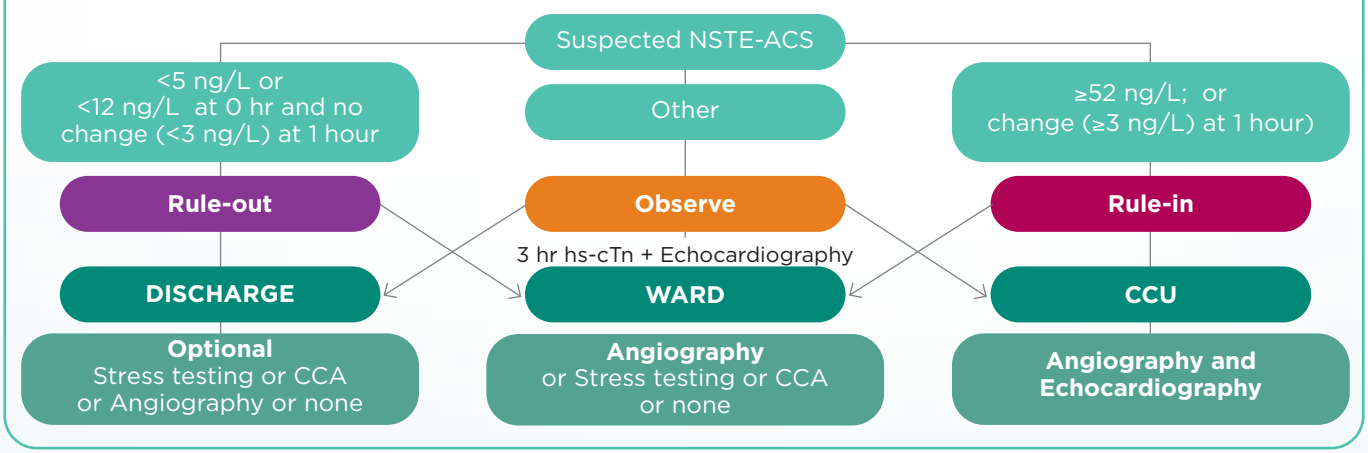
The hs-cTnT 0-hour/1-hour algorithm

Over the past couple of decades, guidelines issued by the European Society of Cardiology (ESC), American Heart Association (AHA) and American College of Cardiology (ACC) mandated the measurement of a biomarker reflecting and quantifying cardiomyocyte injury, preferably cardiac troponin (cTn) I or T, in all patients presenting with suspected ACS.[2,3] Biomarkers like cardiac troponins that complement clinical assessment and 12-lead ECG were recommended to improve the accuracy of diagnosis, risk stratification, triage, and management of patients with suspected ACS.[4]

Early versions of the cTn assays had limited analytical sensitivity to dynamic elevations of cardiac troponin above the 99th percentile reference value in healthy individuals, which is the guideline-mandated cut-off value for myocardial injury.[5]

The development of high-sensitivity cTn (hs-cTn) assays increased the probability of detecting lower cTn concentrations that would differentiate normal from mildly elevated cTn levels, which may occur in smaller infarctions and earlier phases of non-ST-segment elevation MIs (NSTEMI).[5] Evidence showed that hs-cTn assays increased the accuracy of acute MI diagnosis at the time of presentation to the ED. The benefit of these assays was most pronounced in patients presenting early after chest pain onset.[4]

Figure 3. The ESC-recommended 0-hour/1-hour rule-in and rule-out algorithm using the hs-cTnT assay (Elecsys® Troponin T high-sensitivity assay, Roche Diagnostics) in haemodynamically stable patients presenting with suspected NSTEMI, as applied in IJN's emergency department



Observe patients who do not qualify for 'rule-out' or 'rule-in'. These patients are heterogeneous and usually require a third measurement of cardiac troponin at 3 hours and echocardiography.

CCU, coronary care unit; CCTA, coronary computed tomography angiography; CPO, chest pain onset; hs-cTn, high-sensitivity cardiac troponin; NSTE-ACS, non-ST-segment elevation acute coronary syndrome; NSTEMI, non-ST-segment elevation myocardial infarction.

Adapted from Collet JP, Thiele H, Barbato E, et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J. 2021.

With the improved sensitivity for the detection of acute MI at presentation, the interval between serial measurements of hs-cTn could be shortened, which reduced delays to diagnosis, shortened stays in the ED and lowered costs.[2,4]

The 2023 ESC guideline recommended the 0-hour/1-hour algorithm as the first-choice diagnostic algorithm with the hs-cTnT assay in haemodynamically stable patients presenting with suspected NSTEMI (Class I, Level B), followed by the 0-hour/2-hour algorithm. The recommended algorithm required that blood samples are taken immediately upon presentation and again at 60 minutes, once results of the first test are reported. The same guideline downgraded the recommendation for the 0-hour/3-hour algorithm. The basis for this recommended interval was that cardiac troponin levels rise rapidly, usually within an hour of symptom onset (***Figure 3***).[2]

Several studies demonstrated that the hs-cTnT 0-hour/1-hour algorithms supported early rule-in/rule-out triaging of patients with suspected ACS,[6-8] with high negative predictive value and sensitivity for acute MI within the rule-out cohort.[6]

The RAPID-TnT trial (Rapid Assessment of Possible ACS in the Emergency Department with High-Sensitivity Troponin T) was a prospective patient-level randomized noninferiority evaluation of a 0-hour/1-hour hs-cTnT protocol (reported to the limit of detection [<5 ng/L]) (n=1646) compared to a 0-hour/3-hour protocol with troponin T (results masked at <29 ng/L) (n=1642), in participants with suspected ACS, with respect to death or MI by 30 days. Participants in the 0-hour/1-hour arm were:[8]

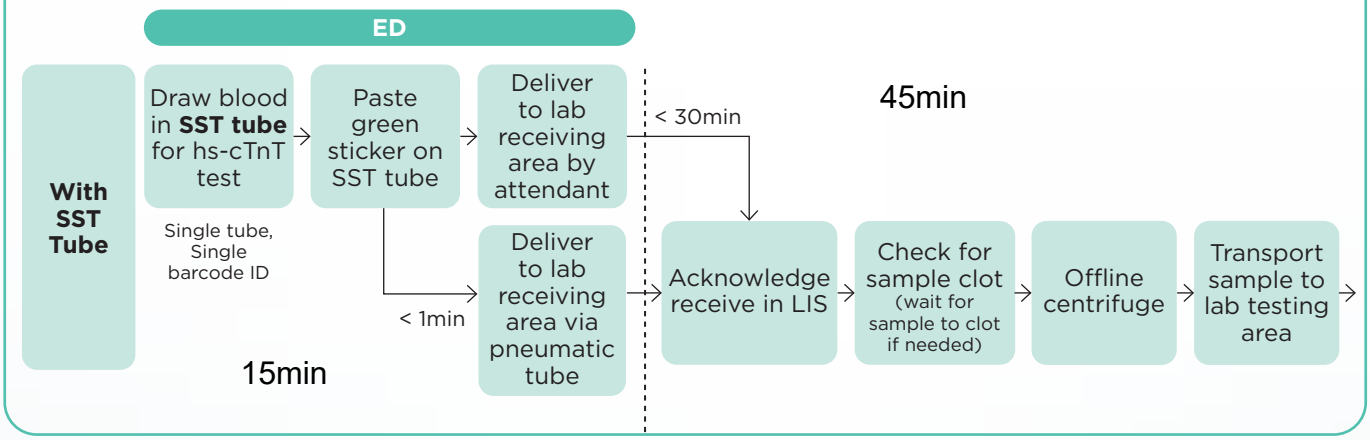
- more likely to be discharged from the ED than patients in the 0-hour/3-hour arm (45.1% versus 32.3%, P<0.001).
- had a shorter length of stay in the ED (median 4.6 versus 5.6 hours, P<0.001)
- were less likely to undergo functional cardiac testing (7.5% versus 11.0%, P<0.001).

Importantly, the 0-hour/1-hour protocol had a negative predictive value of 99.6% (95% CI, 99.0–99.9%) for 30-day death or myocardial infarction among patients discharged from ED.[8]

Incorporating the hs-cTnT 0-hour/1-hour algorithm into IJN's revamped clinical pathway in the ED and workflow in the laboratory

The implementation of the hs-cTnT 0-hour/1-hour algorithm in IJN's ED, however, required solutions for delays in the testing turnaround time, specifically delays in transporting urgent hs-cTnT samples to the laboratory (particularly after office hours) and delays in reporting test results back to the ED. Hence, the Chest Pain Patient Process Improvement Project group also developed a revamped workflow for the laboratory to ensure results were reported within a timely manner ***(Figure 4)***.

Figure 4. New proposed workflow for hs-cTnT samples received in IJN's laboratory



ED, emergency department; ID, identification; LIS, laboratory information system; hs-cTnT, high-sensitive cardiac troponin T; SST, serum separating tube

The new workflow proposed that target turnaround time from ordering of the hs-cTnT assay to reporting of results should not exceed 60 minutes, specifically:

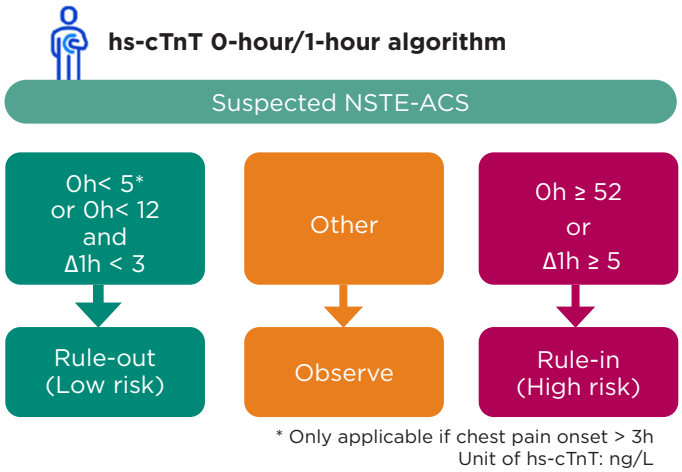
- The time from when hs-cTnT is ordered in the ED to when the sample is received in the laboratory should be within 15 minutes.
- The time from when the sample is received in the laboratory to when the result is released should be within 45 minutes.

Changes included:

- Introduction of dedicated hs-cTnT blood sampling trolleys and time-based tracking forms for blood sampling in the ED.
- Transport of urgent samples to the laboratory by hand.
- Different tubes (red SST tube and green lithium heparin tube) were tested for shorter centrifuge times (1, 5, 10 minutes) and to determine if they were inter-changeable. However, correlation studies showed low inter-changeability. Hence, the red SST tubes were used and labelled with '0-hour' and '1-hour' in green. This was later upgraded to short red SST tubes with dedicated red biohazard bags for ease of identification by the laboratory and computerized labelling for 0-hour and 1-hour samples.
- Targeted training for ED and laboratory personnel.
- Continued engagement with ED and laboratory personnel to assess effectiveness of the new workflows and identify problems.

Information dissemination to doctors was key to ensuring timely assessment and blood sampling. The project group developed a quick reference card for doctors on the principles of the hs-cTnT 0-hour/1-hour algorithm (***Figure 5***) and a patient information sheet that detailed investigations that would be performed in the ED (***Figure 2***). An online education session, led by a cardiologist from Japan and an emergency physician from Taiwan, was also held for IJN's doctors and cardiologists.

Figure 5. The hs-cTnT 0-hour/1-hour algorithm reference card for doctors



It is recommended to base diagnosis and initial short-term risk stratification on a combination of clinical history, symptoms, vital signs, other physical findings, ECG, and laboratory results including hs-cTnT (Class 1, Level B)

The ESC 0-hour/1-hour algorithm with blood sampling at 0h and 1h is recommended of an hs-cTn test with a validated 0-hour/1-hour algorithm is available (Class 1, Level B)

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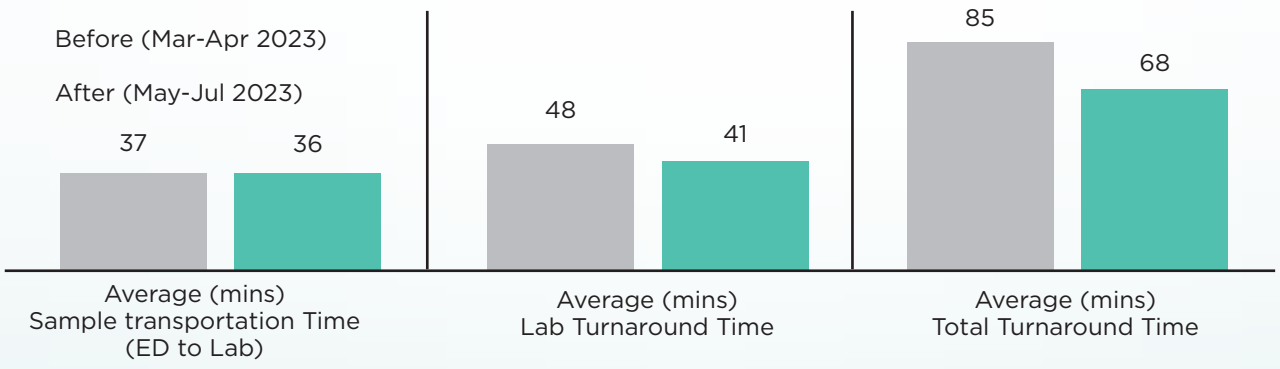
IJN's Process Improvement Project: results following implementation

Upon initiation of the new clinical pathway and the hs-cTnT 0-hour/1-hour algorithm in May 2023, the number of hs-cTnT tests ordered by the ED increased from 4 and 17 in March and April 2023, respectively to 572, 675 and 727 in May, June and July 2023, respectively. The average turnaround time decreased from 85 minutes pre-implementation to 68 minutes post-implementation, which translated as a 33% improvement in turnaround time efficiency (***Figure 6***).[1]

Figure 6. Average turnaround time for hs-cTnT testing in IJN's ED



The average length of stay for 90% of ACS patients in the ED ***decreased by 25 minutes*** from 365 minutes pre-implementation to 340 minutes post-implementation (***Table 2***). There were no patient complaints regarding waiting times following implementation.[1]

Table 2. Mean length of stay for ACS patients in IJN's emergency department

Length of stay	Before (Jan – Mar 2023)	After (May – June 2023)
Minimum (minutes)	45	15
Mean, overall patient population (minutes)	208	199
Median, overall patient population (minutes)	182	176
Mean, 90% of patients (minutes)	365	340
% of patients treated <6 hours	89%	94%

The hs-cTnT 0-hour/1-hour algorithm was safe, as the number of repeat visits ED within 24 hours of discharge among patients with low-risk chest pain remained unchanged following implementation of the algorithm (2, 0 and 4 repeat visits in February, March and April, respectively versus 4, 1 and 3 repeat visits in May, June and July, respectively).

As part of the ongoing assessment of the effectiveness of the algorithm, 762 consecutive patients who presented at IJN's ED with chest pain were reviewed. The algorithm effectively triaged 72.7% of patients in the cohort as either rule in or rule out, which was comparable to the published rate of 77.8% reported in the Rapid-TnT trial.[8]

Key conclusions

1. The revamped clinical pathway and workflow in the laboratory improved triage efficiency by reducing turnaround time for hs-cTnT testing by 33%, which reduced the average length of stay at the ED by 25 minutes for 90% of patients.
2. There was no increase in repeat visits within 24 hours post discharge among patients with low-risk chest pain, which supported the evidence that the hs-cTnT 0-hour/1-hour algorithm allows for the rapid discharge of patients presenting with low-risk chest pain.
3. Collectively, these results have encouraged greater compliance to the new algorithm and improved doctors' confidence when managing patients with chest pain.
4. This in turn, promotes greater standardization of care for patients, which improves patients' safety and reassures patients and family members when patients are discharged.
5. The multidisciplinary collaboration between stakeholders within the ED and laboratory is a critical factor in the ongoing assessment of, and improvement to the management of chest pain patients.

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