



Quality Improvement

Reducing Unnecessary Noninvasive Testing for Inpatients With Unstable Angina: The RUNIT Protocol

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ABSTRACT

Background: Routine inpatient transthoracic echocardiography (TTE) for patients with unstable angina is common, but it anecdotally adds little value to clinical care. A practice audit at our academic hospital demonstrated that 61.5% of patients with troponin-negative chest pain (TNCP) had normal left ventriculography (LVG) during coronary

RÉSUMÉ

Contexte : La réalisation systématique d'une échocardiographie transthoracique (ETT) chez les patients hospitalisés pour angine instable est une pratique courante, qui n'apporte toutefois qu'une valeur anecdotique aux soins cliniques. Un audit des pratiques en vigueur dans l'hôpital universitaire auquel nous sommes rattachés a

Echocardiography is essential to the management of patients with cardiovascular disease but represents a major expense to health care systems due to its widespread use.^{1,2} Even so, patients in the United States, and conceivably elsewhere, have limited transthoracic echocardiography (TTE) access that may increase their mortality.³ Given these troubling findings, attempts at improving access by promoting TTE stewardship were made by the American College of Cardiology Foundation and member organizations with the introduction of the appropriate use criteria (AUC).⁴ Unfortunately, Rahimi et al., along with a number of other studies, demonstrated that despite the intervening publication of the AUC, there has been little improvement in the number of inappropriate TTE referrals.^{5,6}

The more fundamental limitation of the AUC, which our intervention hoped to address, is that appropriateness is not synonymous with necessity; appropriate studies by criteria⁴ may not be clinically meaningful for that patient.^{7,8} At our academic centre, patients admitted with unstable angina

(UA)—new onset or rapidly progressive typical angina⁹ in a patient with compelling cardiovascular risk factors but negative high-sensitivity troponin T values (<50 ng/L)—routinely get an inpatient TTE to assess wall motion and ejection fraction. By AUC criteria on a scale of 1 (least appropriate) to 9 (most appropriate), this indication is classified a 9 as an “appropriate test for [the] specific indication.”⁴ However, in our experience, this TTE rarely changes management; these patients with troponin-negative chest pain (TNCP) generally also undergo coronary angiography and left ventriculography (LVG). Moreover, they will have undergone a history and physical examination to screen for clinically important valvular disease, heart failure, and structural heart disease. Despite this, a culture has been perpetuated at our centre that these patients required both a TTE and LVG (duplicate testing). This was particularly problematic, as local audit data suggested that our noninvasive imaging department was overwhelmed with requisitions, and noncardiology services were waiting significantly longer for in-hospital echocardiography.

From the perspective of overuse, we considered TTE to be the redundant test. First, TTE is variably performed before or after angiography in our centre. Thus, patients could have normal coronary angiography and normal LVG but still continue to wait on the ward for inpatient TTE, especially if there were many inpatient TTE requisitions that week. As a result, we wanted our intervention to give the opportunity for immediate discharge of patients with normal angiography and LVG, as this was the main limiting step to ruling out

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Ethics Statement: The research reported has adhered to the National Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans.

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angiography and normal TTE on the same admission (duplicate testing).

Methods: We developed the **Reducing Non-Invasive Testing (RUNIT)** protocol, a clinical algorithm applied by clinical nurses to patient with TNCP. We performed a prospective assessment of rate of duplicate testing before and after intervention. If patients met certain simple clinical criteria, their TTE was cancelled (RUNIT positive). Patients then proceeded to have either coronary angiography with LVG or noninvasive risk stratification. We aimed to reduce duplicate testing by 25% over a 1-year period. Balancing measures included pathology on ordered TTEs, 30-day readmission, length of stay, and number of LVG.

Results: Among 254 patients admitted with TNCP over 12 months, we reduced duplicate testing from 61.5% (before intervention) to 34% ($P = 0.001$). There was no clinical difference in 30-day readmission (0.9% vs 0.7%), and length of stay was significantly shorter in RUNIT positive (3.48 vs 4.16 days, $P = 0.02$). The majority of duplicate TTEs did not reveal any management-informing pathology. RUNIT-positive patients underwent more LVG than RUNIT-negative patients (78.3% vs 62.8%, $P = 0.008$).

Conclusion: We achieved a sustained reduction in reflexive TTE ordering in patients with TNCP, and we discuss the potential of nursing-led interventions to address other areas of low value care in cardiology.

significant coronary disease. Second, the practice of LVG by interventionalists at our centre is pervasive and adds little time to the procedure. It also provides a good estimate of ejection fraction and a reasonable assessment of mitral regurgitation, aortic regurgitation, and aortic stenosis.

Studies have shown that audit-and-feedback interventions^{10,11} have had the most success at promoting TTE stewardship, whereas educational interventions and AUC prompts designed to support decision-making on computerized physician entry systems have not clearly led to sustained change in ordering behaviour.^{12,13} In the latter case, the authors suggested that prompt fatigue was a barrier to success. We designed a clinical protocol that could be applied by nurses to admitted patients to reduce the number of duplicate testing in TNCP inpatients and demonstrate the safety of deferring their TTE. The aim of our intervention was to reduce the rate of duplicate testing in this population by 25%, similar to other inpatient interventions,¹¹ and sustain this change over a 1-year period.

Methods

Setting and initial evaluation

Between November 2018 and October 2019, our academic hospital admitted 1699 patients to the cardiology ward,

révéla que 61,5 % des patients ayant une douleur thoracique sans élévation de la troponine (DTST) présentaient une ventriculographie gauche (VGG) normale à la coronarographie et une ETT normale lors de la même admission (tests effectués en double).

Méthodologie : Nous avons mis au point le protocole RUNIT (*Reducing Non-Invasive Testing*, réduction des tests non invasifs), un algorithme clinique appliqué par le personnel infirmier clinicien aux patients présentant une DTST. Nous avons ensuite mené une évaluation prospective du taux de réalisation de tests en double avant et après l'intervention. Si les patients répondaient à certains critères cliniques simples, l'ETT n'était pas effectuée (score RUNIT positif). Les patients ont par la suite été soumis soit à une coronarographie et à une VGG, soit à une stratification du risque associé aux méthodes non invasives. Notre objectif était de réduire de 25 % la réalisation de tests en double sur une période de 1 an. Les mesures de compensation comprenaient une évaluation pathologique des résultats des ETT demandées, la réadmission à 30 jours, la durée de l'hospitalisation et le nombre de VGG.

Résultats : Parmi les 254 patients admis en raison d'une DTST sur une période de 12 mois, nous avons réduit la réalisation de tests en double de 61,5 % (avant l'intervention) à 34 % ($p = 0,001$). Il n'y avait pas de différence clinique quant au taux de réadmission à 30 jours (0,9 % vs 0,7 %), et l'hospitalisation a été beaucoup plus courte chez les patients ayant obtenu un score RUNIT positif (3,48 vs 4,16 jours, $P = 0,02$). La majorité des ETT réalisées en double n'ont mis au jour aucune caractéristique pathologique permettant d'éclairer la prise en charge. Les patients qui ont obtenu un score RUNIT positif ont par ailleurs subi un plus grand nombre de VGG que ceux qui ont obtenu un score négatif (78,3 % vs 62,8 %, $p = 0,008$).

Conclusion : Nous avons réussi à réduire de manière soutenue la réalisation systématique d'ETT chez les patients présentant une DTST, et nous traitons de la possibilité de mettre en place des protocoles à appliquer par le personnel infirmier afin de réduire l'exécution d'autres interventions n'apportant que peu de valeur aux soins en cardiologie.

and the cardiology ward service consists of a cardiologist and 2 nurse clinicians. During the same above time frame, 3222 diagnostic coronary angiograms were performed on both outpatients and inpatients of which 1253 (39%) were converted to angioplasty cases. Our rate of normal coronary angiography over that span was 11.2%, which is low compared with published 2013 data from Canada.¹⁴ Our institution does not routinely track the number of TTEs ordered by each inpatient service. However, a 1-month practice audit suggested that 60% of inpatient TTEs at our institution are ordered by the inpatient cardiology service. Thus, given that our academic hospital performed 4174 inpatient TTEs between November 2018 and October 2019, we assume that 2504 were ordered by cardiology.

Furthermore, the 1-month practice audit also revealed that a total of 61.5% ($n = 19$ of 31) had a normal LVG during coronary angiography in addition to a subsequent normal TTE on the same admission (which is much higher than the rate of 20% reported in a study of patients hospitalized with acute myocardial infarction, where one would expect duplicate testing to be higher than in our TNCP population).¹⁵ We rigorously explored the reasons for this duplicate ordering (see [Supplemental Table S1](#)). Ultimately, there appeared to be a pervasive culture that every admitted cardiology patient needs a TTE; an inpatient TTE on such patients was opportunistic

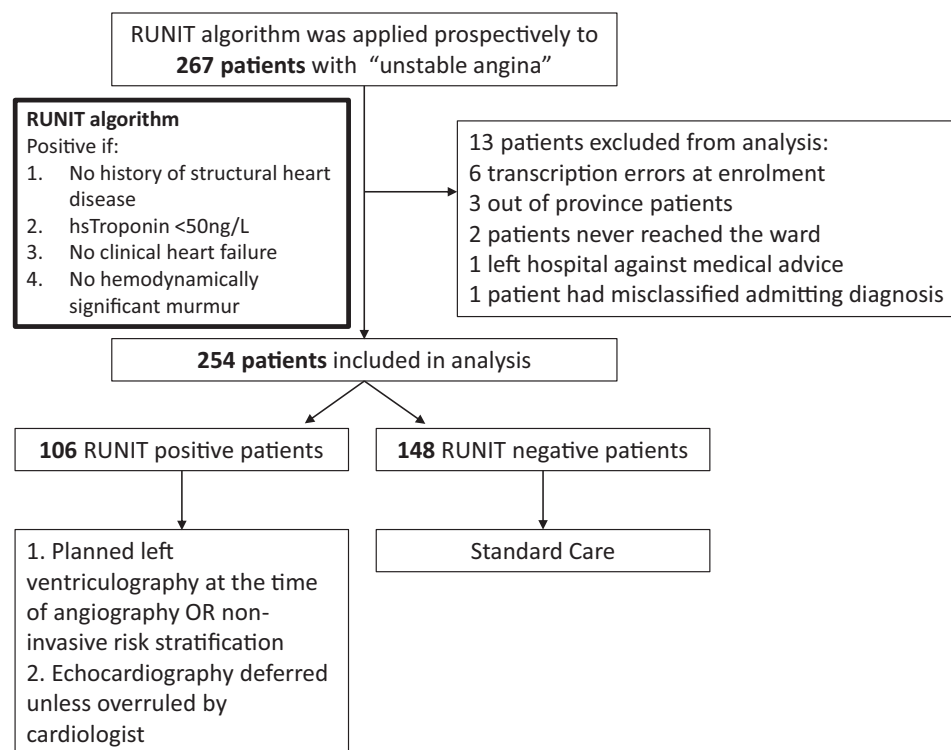


Figure 1. Screening criteria, group assignment. RUNIT, **R**educing **N**on-**I**nvasive **T**esting.

and could reassure the clinician that no valvular or anatomic abnormalities had been missed, even if these diagnoses were not being considered based on the admission history or physical examination. In addition, the most recent ACC/AHA guidelines¹⁶ recommend a ventricular assessment for each patient admitted with an acute coronary syndrome with a preference for echocardiography.

Against this backdrop, our intervention aimed to reassure the attending cardiologist that, in the absence of other compelling indications, an inpatient TTE could reasonably be deferred in selected patients with UA. At the very least, it could be deferred until outpatient clinical follow-up. After multiple Plan-Do-Study-Act cycles (see [Supplemental Table S1](#)), we designed a nursing-led intervention integrating clinical data to reduce low-yield TTE ordering for patients with TNCP. This intervention had the advantages of (1) being simple and reproducible, (2) involving nurses who had not already been biased by our local ordering culture, and (3) integrating seamlessly into nursing workflow.

Intervention

Using a pre- and postintervention design, we prospectively tracked the rate of duplicate studies for patients with TNCP admitted with UA compared with the rate obtained from our 1-month practice audit (see the Setting and initial evaluation section). Our “**R**educing **N**on-**I**nvasive **T**esting (RUNIT) protocol” clinical algorithm ([Fig. 1](#)) was applied to these patients to determine if an ordered TTE was *clinically* appropriate, or if it should be withheld (termed *RUNIT positive*). Accordingly, RUNIT-positive patients had their TTE withheld pending discussion with the admitting cardiologist.

If, however, according to the algorithm, the patient had a reasonable indication for an inpatient TTE (*RUNIT negative*), no action was taken (see [Fig. 1](#)). Patients were identified for the intervention based on the admitting diagnosis of “UA.” Furthermore, the catheterization laboratory nurse coordinator took note of RUNIT-positive patients and reminded the interventional cardiologist of the need for LVG at the time of coronary angiography. Left ventricular angiography used a standard single plane right anterior oblique (RAO). A single RAO view of LV angiography has reasonable correlation with TTE determined ejection fraction.¹⁷

When noninvasive coronary risk stratification was felt to be more appropriate, the cardiologist was at liberty to pursue that option instead of coronary angiography. A pre-existing protocol to question TTE requisitions on patients who had recent echocardiography at our hospital (within 6 months) already existed, which is why we did not include this in the RUNIT protocol.

The nurse clinicians were responsible to apply the RUNIT protocol initially under direct physician supervision to establish a safe protocol and this led to some minor modifications. Ongoing feedback allowed improvement of the intervention during the planning and execution phases (see [Supplemental Table S1](#)).

Measures

For our primary outcome, we calculated the percentage of patients admitted with UA who underwent duplicate testing. To estimate fidelity of the intervention, the list of RUNIT patients (positive or negative) was compared with all those who underwent coronary angiography or noninvasive testing

Table 1. Baseline Characteristics of RUNIT negative and RUNIT positive patients

Baseline characteristics	All	RUNIT negative (n = 148)	RUNIT positive (n = 106)	P value
Age, mean (SD)	66.1 (11.2)	68.2(10.6)	63.2 (11.6)	< 0.001*
Female, n (%)	87 (34.3)	44 (29.7)	43 (40.6)	0.07
Risk factors, n (%)				
Hypertension	185 (72.8)	113 (76.4)	72 (67.9)	0.13
Smokers	79 (31.1)	49 (33.1)	30 (28.3)	0.41
Hx of CAD	122 (48.0)	115 (77.7)	7 (6.6)	< 0.001
Hx of DM	85 (33.5)	66 (44.6)	19 (17.9)	< 0.001
FMHx prem. CAD	7 (2.8)	2 (1.4)	5 (4.7)	0.13 [†]
Dyslipidemia	172 (67.7)	105 (70.9)	67 (63.2)	0.19
Procedure details, n (%)				
TTE performed	124 (48.8)	81 (54.7)	43 (40.6)	0.02
LVG performed	176 (69.3)	93 (62.8)	83 (78.3)	0.008
TTE EF > 50%	98 (79.0)	58 (71.6)	40 (93.0)	0.005
LVG EF > 50%	145 (82.9)	66 (71.7)	79 (95.2)	< 0.001
Coronary catheterization details, n (%) [‡]				
LM stenosis (> 50%)	19 (7.9)	12 (8.6)	7 (7.1)	0.67
LM PCI	1 (0.4)	1 (0.7)	0	0.99 [†]
LAD stenosis (> 50%)	113 (47.3)	69 (49.3)	44 (44.4)	0.46
LAD PCI	50 (19.8)	26 (17.7)	24 (22.9)	0.31
RCA stenosis (> 50%)	93 (38.9)	64 (45.7)	29 (29.3)	0.01
RCA PCI	35 (13.9)	26 (17.7)	9 (8.6)	0.03
LCx stenosis (> 50%)	77 (32.2)	59 (42.1)	18 (18.2)	<0.001
LCx PCI	22 (8.7)	14 (9.5)	8 (7.6)	0.59
Multivessel PCI	14 (5.5)	7 (4.7)	7 (6.6)	0.54
Inpatient CABG	20 (7.9)	9 (6.1)	11 (10.4)	0.21
Outpatient follow-up planned, n (%)				
Family physician	245 (96.5)	145 (98.0)	100 (94.3)	0.17 [†]
Internal medicine	21 (8.3)	15 (10.3)	6 (5.7)	0.19
Cardiology	201 (79.1)	133 (89.9)	68 (64.2)	< 0.001

CABG, coronary artery bypass grafting; CAD, coronary artery disease; DM, diabetes mellitus; EF, ejection fraction; FMHx, family history; Hx, history; LAD, left anterior descending; LCx, left circumflex; LM, left main; LVG, left ventriculography; PCI, percutaneous coronary intervention; RCA, right coronary artery; RUNIT, **R**educing **N**on-**I**nvasive **T**esting; SD, standard deviation; TTE, transthoracic echocardiography.

* T-test used.

[†] Fisher's exact test used.

[‡] Does not include 15% of patients who underwent noninvasive coronary stratification only.

for UA over the intervention period. Secondary balancing and safety outcomes were length of stay, 30-day readmission to one of our local hospitals with a cardiac complaint, and number of LVG performed during coronary angiography. Furthermore, we reported any new cardiac abnormalities on TTEs performed in RUNIT-positive patients, in addition to any outpatient TTEs performed in the ensuing 3 months. Finally, the protocol was amended after the 54th patient was recruited to document reasons why cardiologists were overruling the protocol despite normal ventriculography.

Analysis

The difference between primary outcome before and after intervention was assessed using 2-tailed confidence intervals of independent proportions. Secondary outcomes were compared using 2-tailed independent *t*-tests where sample sizes allowed. Baseline characteristics of RUNIT-positive and RUNIT-negative patients were compared using independent *t*-tests for continuous variables and χ^2 testing/Fisher's exact test for categorical variables. The study was approved by the University of Saskatchewan Biomedical Research Ethics Board, and the need to obtain informed consent was waived.

Results

Patient characteristics

Of 267 patients considered for enrolment, 13 were excluded, leaving 254 patients in the final analysis (see Fig. 1). Fidelity of the intervention was > 90%. We gathered baseline characteristics comparing RUNIT-positive (n = 106) and -negative (n = 148) patients including age, gender, traditional cardiovascular risk factors, coronary anatomy, procedures performed, and intended follow-up (Table 1). RUNIT-positive patients were younger (*P* < 0.001) and less likely to have a history of diabetes mellitus or coronary artery disease (*P* < 0.001) compared with RUNIT-negative patients. They were also less likely to have an inpatient TTE performed (*P* = 0.02, Fig. 2). When a TTE was performed despite the direction of the protocol, the ejection fraction was more likely to be normal (*P* = 0.005). RUNIT-positive patients had more LVG performed compared with RUNIT-negative patients (*P* = 0.008). Dedicated cardiology follow-up was more often arranged in RUNIT-negative patients (*P* < 0.001), but family physician follow-up was >90% in each group (*P* = 0.17).

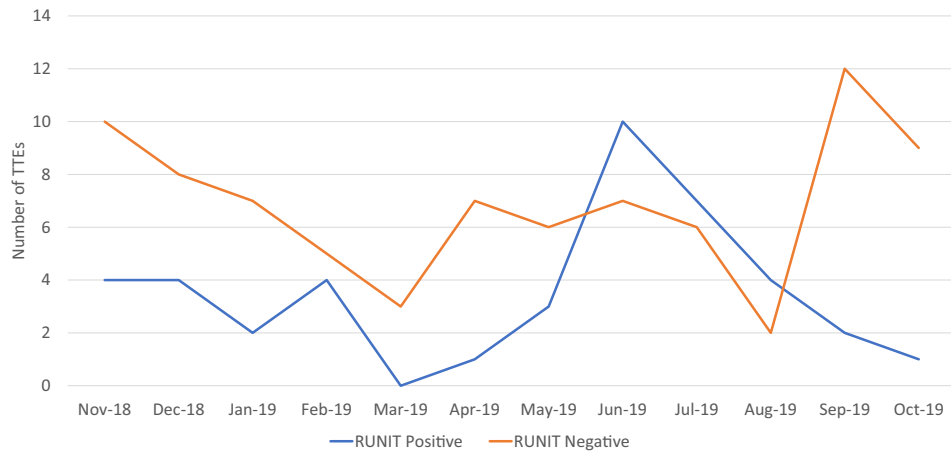


Figure 2. Run chart of total monthly TTEs performed according to **Reducing Non-Invasive Testing (RUNIT)** group assignment.

With regard to our primary end point, we reduced duplicate testing to 34% ($P < 0.001$) over the 1-year period compared with our preintervention rate of 61.5% (based on chart audit). It is noteworthy that the rate of duplicate testing was continuing to decline below 30% during the last recorded 3 months of the intervention (Fig. 3). This translated into an absolute reduction of 61 TTEs in this patient population (2.4% of all cardiology-ordered TTEs over the year). Interestingly, duplicate testing was reduced in both RUNIT-positive and -negative patients during the intervention period (31.1% vs 34.5%, $P = \text{NS}$). If patients with prolonged hospital stays as a result of inpatient coronary artery bypass grafting are excluded, there was a shorter length of stay in RUNIT-positive patients (3.48 vs 4.16 days, $P = 0.02$). There was no difference between the groups in 30-day readmission (0.9% vs 0.7%, $n = 2$). One of the RUNIT-positive patients who had inpatient percutaneous angioplasty and normal TTE subsequently died unexpectedly of liver failure. There were no other fatalities in the RUNIT-positive group.

Of the RUNIT-positive patients who proceeded to have normal LVG, 28 underwent inpatient TTE anyway at the discretion of the attending cardiologist who overruled the protocol. When reported, the reasons for overruling the protocol are listed in Table 2. Of these 28 inpatient TTEs,

61% had no reported abnormalities, 18% had regional wall motion abnormalities, 14% had mild diastolic dysfunction, and 4% ($n = 1$) had mild systolic dysfunction (Fig. 4). Moreover, in our sample, single-view RAO LVG and TTE estimates of ejection fraction agreed 88% of the time ($\kappa = 0.66$, $n = 85$).

Fourteen RUNIT-positive patients had outpatient TTEs performed within 3 months of discharge. One of these showed mildly reduced ejection fraction, 2 showed a mild wall motion abnormality, 1 showed moderate (grade 2) diastolic dysfunction, and the other 10 were normal. The majority of patients were discharged with the diagnoses of “UA” or “chest pain not yet determined” (Fig. 5).

Finally, RUNIT-positive patients were less likely to have coronary stenoses than RUNIT-negative patients (35.95% vs 64.05%, $P = 0.02$). Overall, the rate of obstructive coronary artery disease (stenoses $>50\%$) in the sample was 60%. There was a higher rate of percutaneous coronary intervention in the RUNIT-negative patients, though this was not statistically significant (44.72% vs 36.26%, $P = 0.19$).

Discussion

Our clinical algorithm to select inpatients with UA in whom TTE could be deferred reduced duplicate ventricular

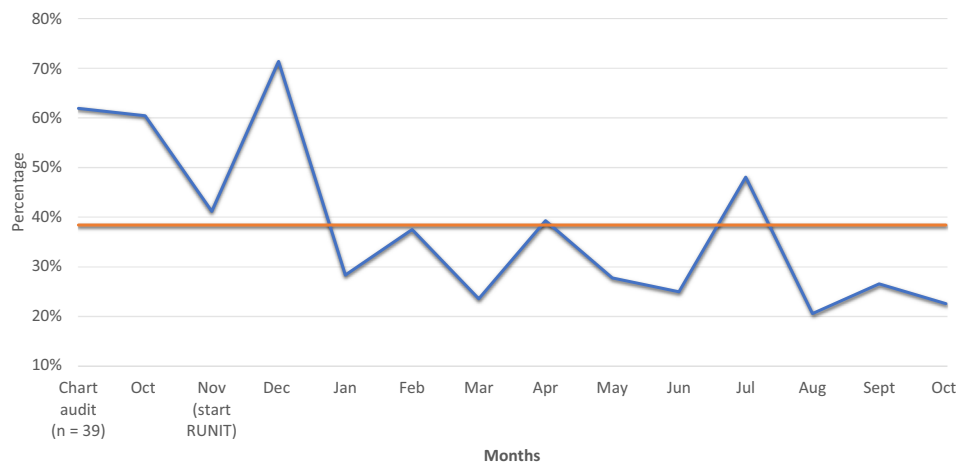


Figure 3. Run chart of percentage of duplicate studies per month before and after intervention (**Reducing Non-Invasive Testing [RUNIT]** protocol).

Table 2. Reasons given by ward cardiologists for overruling runit protocol during the study period

Reason for overruling protocol	Frequency (n = 28)
Preoperative assessment pre-CABG	4 (14.3)
Suspicion of arrhythmia	2 (7)
BNP elevated	1 (4)
Left heart catheterization cancelled	1 (4)
Valvular lesion suspected	1 (4)
Hx of DM	1 (4)
Atypical symptoms	1 (4)
Previous MI	1 (4)
Echocardiography performed in ED	1 (4)
Unknown	13 (46)

Data represent n (%).

BNP, brain natriuretic peptide; CABG, coronary artery bypass grafting; DM, diabetes mellitus; ED, emergency department; Hx, history; MI, myocardial infarct.

assessments by 27.5%. This presumably reallocated 61 inpatient TTEs to other inpatients with more meaningful indications for echocardiography. If each TTE costs the system approximately \$450 based on our local insurance schedule,^{18,19} our intervention has the potential to redirect >\$25,000 of annual hospital expenses to more useful clinical imaging. This deferral of testing also missed few management-informing pathology and other diagnoses (Fig. 3). Furthermore, with the caveat that the algorithm selects for lower risk patients, length of stay was also shorter in RUNIT-positive patients who had their TTE deferred. Based on the above, our intervention improves access to TTE for patients with more urgent indications, reduces hospital costs, and minimizes the risk of hospital-acquired infection through reduction in length of stay.²⁰

Unlike educational interventions that are vulnerable to waning in effectiveness over time,²¹ our protocol was consistently applied over the 1-year period as evidenced by high intervention fidelity. Another marker of a successful intervention is that the targeted change in behaviour appeared to become engrained or “part of the culture.” Indeed, the fact that RUNIT-negative patients also experienced a lower rate of duplicate studies suggests that the change in the ordering pattern was adopted and applied outside the protocol, a

feature associated with other successful initiatives.^{22,23} This culture change was likely the main cause of the reduction in TTE ordering, highlighting the importance of not only the intervention but also education endeavours including our audit, feedback, and grand rounds.

Reasons for overruling the protocol were systematically gathered during the intervention (Table 2). The most common reason was preoperative evaluation before inpatient coronary artery bypass grafting, followed by arrhythmia (non-sustained ventricular tachycardia in both cases). The other listed reasons were also defensible. A large proportion were unknown, either because the cardiologist did not make it clear or this discussion did not occur. As a result, we are left to speculate why these other TTEs were ordered. Anecdotally, a significant proportion of patients from geographically remote centres are treated in our hospital. Thus, some care providers may have ordered an inpatient TTE to close a potential care gap in a patient who would be theoretically challenging to follow up as an outpatient. Moreover, TTEs were ordered routinely based on misinterpreted ACC/AHA guidelines¹⁶ that each patient with acute coronary syndrome requires an inpatient TTE, where it recommends a ventricular assessment only. The assessment in this case predicts prognosis primarily, with a TTE providing the additional benefit of giving structural and functional cardiac information and ruling out other diagnoses.¹⁶ However, if no significant myocardial or valvular abnormality is suspected, such as in the case of RUNIT-positive patients, this is likely a redundant test with little added value. Instead, our results suggest that these patients could be re-evaluated as an outpatient for further noninvasive testing.

The practice of assurance behaviour,^{24,25} like ordering a TTE on a patient with UA “just in case,” will vary considerably among physicians. For example, at our centre, important practice variation exists related to when patients are safe to transfer to the ward from the coronary care unit after ST-elevation myocardial infarction, when it is safe to discontinue telemetry on inpatients, or which antithrombotic regimen to prescribe a patient (to name a few). Unnecessary variation is confusing for nursing, referring physicians, and negatively impacts patient care.²⁶ We believe that employing standard protocols applied by nurse clinicians, or other allied health

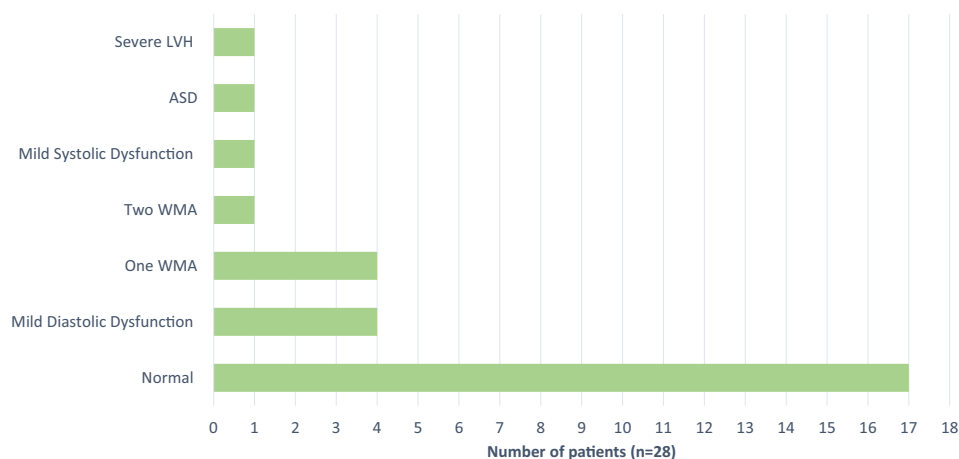


Figure 4. Duplicate TTE results in RUNIT-positive patients with normal left ventriculography (does not include patients who had abnormal LVG or no LVG, n = 18). LVG, left ventriculography; RUNIT, Reducing Non-Invasive Testing; TTE, transthoracic echocardiography.

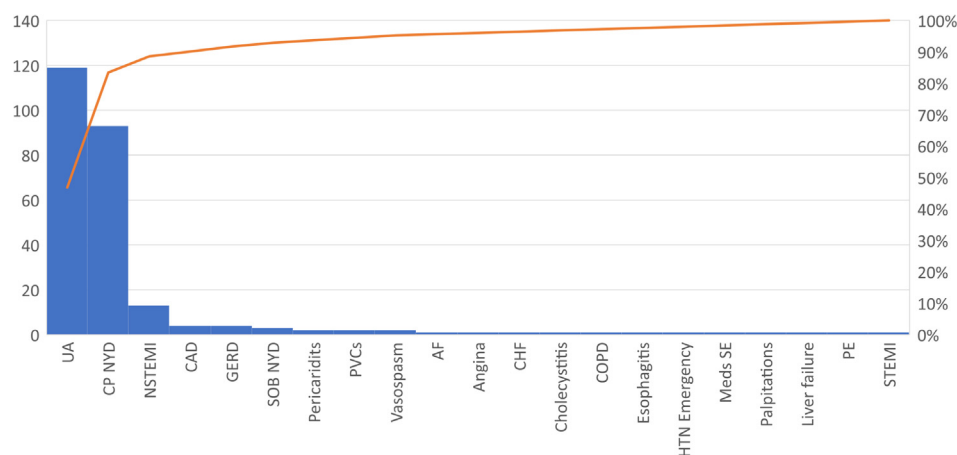


Figure 5. Discharge diagnoses of all **Reducing Non-Invasive Testing** (RUNIT) patients (N = 254). AF, atrial fibrillation; CAD, coronary artery disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CP NYD, chest pain not yet determined; GERD, gastroesophageal reflux disease; HTN, hypertension; NSTEMI, non-ST-elevation myocardial infarct; PE, pulmonary embolism; PVC, premature ventricular complex; SE, side effects; STEMI, ST-elevation myocardial infarct; SOB NYD, shortness of breath not yet determined; UA, unstable angina.

professionals, has tremendous potential to clarify these situations. A nurse-applied algorithm for removing urinary catheters reduced the incidence of urinary infections on a general medical ward.²⁷ Ozeke et al.²⁸ published an insightful commentary pointing out that even though the evidence clearly shows benefit for anticoagulation in the elderly atrial fibrillation population, physicians consistently do not act accordingly as the bleeding risk is overemphasized.²⁸ A gentle nudge could help to overcome this emotional response, and our results suggest that a clinical protocol applied by nurses can help insulate physicians from a defensive stance leading to over- or underinvestigation.

There are several limitations to our study. First, the majority of TTE overordering occurs in the outpatient setting,²⁹ which limits the impact of our inpatient intervention to significantly reduce the total number of inappropriate TTE orders. Nonetheless, our intervention could be generalized to the outpatient setting where allied health professionals are enabled to apply a variety of algorithms.^{30,31} Second, given our lack of access to an integrated electronic medical record, our baseline rate of duplicate studies is based on a chart audit sample that is less accurate than if we had been tracking all cases preintervention. However, given the culture change that was experienced during the intervention and the correspondingly high level of duplicate testing in the first months of intervention, we do not feel that an overestimated baseline rate of duplicate testing explains the ordering changes we observed. Third, our high rate of performance of LVG during coronary angiography may limit generalizability of our intervention to centres with a similar practice. Fourth, demographics for patients stratified noninvasively were not collected, which limited our ability to tailor stewardship efforts to this population. Fifth, a routine invasive strategy for the UA/NSTEMI population is not currently recommended.³² Indeed, centres with more robust access to stress echocardiography, computed tomography angiography, positron emission tomography, and other noninvasive modalities will likely have lower rates of angiography in this population

compared with our sample. However, our population had less percutaneous coronary intervention performed than the invasive arms of contemporary negative randomized studies in patients with UA/NSTEMI,³² suggesting that we are using a selective strategy. Supporting this claim is that 15% of our patients were deemed “lower risk” after group assignment, and the ward cardiologist opted for local noninvasive testing options instead. Finally, our rate of CAD mirrors contemporary data in patients with stable coronary artery disease who had angiography performed⁹ and is higher than a large UA population studied in Norway.³³ Anecdotally, we suspect that our experience is similar to other centres, but there is a paucity of published data to support this claim.

Conclusion

The problem of TTE overordering for clinically irrelevant indications is not just an economic burden for a stretched health care system, but it represents an opportunity cost for sicker patients who could be accessing this imaging instead. Our clinical intervention led to a sustained reduction in reflexive TTE ordering in patients admitted with TNCP. This nursing-led intervention has the potential to improve TTE resource allocation. Similar algorithms could be applied to other processes in cardiology that lead to low value testing or to areas of clinical care with significant variation in practice despite clear guidelines.

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Disclosures

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Supplementary Material

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