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Costs of unstructured investigation of unexplained syncope: insights from a micro-costing analysis of the observational PICTURE registry

Nils Edvardsson[1]*, Claudia Wolff[2], Stelios Tsintzos[3], Guido Rieger[4], and Nicholas J. Linker[5]

[1]Sahlgrenska Academy at Sahlgrenska University Hospital, S-413 45 Göteborg, Sweden; [2]Medtronic European Headquarters, Tolochenaz, Switzerland; [3]Medtronic Global Headquarters, Mounds View, MN, USA; [4]Medtronic Bakken Research Center, Maastricht, The Netherlands; and [5]The James Cook University Hospital, Middlesbrough, UK

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Aims The observational PICTURE (Place of Reveal In the Care pathway and Treatment of patients with Unexplained Recurrent Syncope) registry enrolled 570 patients with unexplained syncope, documented their care pathway and the various tests they underwent before the insertion of an implantable loop recorder (ILR). The aims were to describe the extent and cost of diagnostic tests performed before the implant.

Methods and results Actual costs of 17 predefined diagnostic tests were characterized based on a combination of data from PICTURE and a micro-costing study performed at a medium-sized UK university hospital in the UK. The median cost of diagnostic tests per patient was £1114 (95% CI £995–£1233). As many patients received more than the median number of tests, the mean expenditure per patient was higher with £1613 (95% CI £1494–£1732), and for 10% of the patients the cost exceeded £3539. Tests were frequently repeated, and early use of specific and expensive tests was common. In the 12% of patients with types of tests entirely within the recommendations for an initial evaluation before ILR implant, the mean cost was £710.

Conclusion Important opportunities to reduce test-related costs before an ILR implant were identified, e.g. by more appropriate use of tests recommended in the initial evaluation, by decreasing repetition of tests, and by avoiding early use of specialized and expensive tests. A structured multidisciplinary approach would be the best model to achieve an optimal outcome.

Keywords Syncope • Investigation • Cost • Guidelines • Implantable loop recorder

Introduction

The investigation of syncope imposes a significant economic burden on society.[1,2] Healthcare expenditure is substantial since syncope is a common symptom with a variety of potential underlying causes leading to patient visits to physicians, the emergency department, and to hospitalizations after syncope with or without associated trauma.[3] Syncope was the fifth most common cause for an emergency department visit in the UK according to the Hospital Episode Statistics 2011–12.

The diagnostic tests undertaken to find the cause of syncope are important drivers of the cost. Updated guidelines and/or consensus documents present evidence and recommendations on which investigations are most relevant and likely to lead to a diagnosis[4–6] while at the same time less effective measures can be replaced. Guidelines are dynamic documents that are updated as new research produces evidence that justifies changes in recommendations. However, the dissemination and penetration of the messages of guidelines and expert consensus documents are far from satisfactory and clinical practice adapts slowly.[7]

Previous studies have reported substantial costs of evaluating syncope patients and have suggested the adoption of a more systematic patient care pathway.[1,2,8,9] The observational PICTURE (Place of Reveal In the Care pathway and Treatment of patients

* Corresponding author. Tel: +46 708 442298; fax: +46 31 698850. Email: nils.g.edvardsson@telia.com

What's new?

- A microeconomic analysis of the evaluation of unexplained syncope patients identified important cost-saving opportunities.
- There were both over- and under-investigations relative to the current clinical guidelines, and the use of available tests can be more appropriate.
- The early use of specialized tests and the repetition of tests can be reduced.
- The messages of current guidelines have not been sufficiently implemented in real-life clinical practice of unexplained syncope.

with Unexplained Recurrent Syncope) registry reported that an apparent lack of structured care pathways leads to significant over-investigation of unexplained syncope before patients received an implantable loop recorder (ILR).[10] Reasonably, this influenced the cost of evaluation of the patients, partly because tests could be repeated many times and also because patients undergo various expensive diagnostic tests with a low diagnostic yield. An earlier rather than a later ILR implant reduced the number of preimplant tests without reducing the diagnostic yield.[11]

The aims of the present microeconomic analysis—based on the large, international, PICTURE registry—were to provide costs of diagnostic tests.

Methods

The design, methods, and main results of the PICTURE registry have been previously reported.[10] Briefly, 570 patients with recurrent, unexplained syncope were enrolled and the interpretation of the term 'unexplained' was left to the physicians' discretion. Their median number of syncope episodes was 4 (inter-quartile range, IQR, 2–5), and 3 (IQR 2–4) of them occurred during the 2 years preceding the ILR implant. The median time interval between the first and last episode was 2 years (IQR 0–4). The purpose was to document the care pathway in patients eventually implanted with an ILR as well as to examine the diagnostic yield of the ILR. The study protocol complied with the Declaration of Helsinki and was approved by the relevant locally appointed ethics committee. All patients provided their informed consent. An important finding of PICTURE was that a large number of diagnostic tests were performed, many of them despite a low probability of providing a diagnosis. The present analysis focused on the preimplant diagnostic evaluation, while other costs, such as specialist visits in relation to syncope, admissions to the emergency room, and/or hospitalizations or those caused by severe trauma associated with syncope (defined as fracture or injury with bleeding), were not assessed.

The costs of diagnostic tests were collected from a medium-sized UK university hospital since only few costs of diagnostic tests were available from data sets such as the UK NHS reference costs. The costs of diagnostic tests from the micro-costing study and the NHS reference costs 2009/10, when available, were similar, as summarized in *Table 1*.[12] The median and mean costs of diagnostic tests per patient were calculated as the total number of tests recorded in the PICTURE registry multiplied by the estimated cost of the test in the micro-costing study.

Table 1 Costs of tests

Test	Costs		Patients tested (%)
PICTURE study	Syncope costing study	National reference costs 2009/10	
Standard electrocardiogram	£37	£33	98
Echocardiography	£47	£32	86
Basic laboratory tests	£24	–	86
Ambulatory ECG monitoring	£118	£60	67
In-hospital ECG monitoring	£42	£60	55
Exercise testing	£78	£75	52
Orthostatic blood pressure movements	£11	–	48
Neurological or psychiatric evaluation	£111	–	47
MRI or CT scan	£149	£77–£244	47
Carotid sinus massage	£55	–	36
EEG	£180	–	39
TILT test	£100	–	35
Electrophysiology testing	£1392	–	25
Coronary angiography	£1285	–	23
External loop recording	£147	–	12
'Other tests' = outpatient consultation	£163	–	9
Adenosine triphosphate (ATP) test	£70	–	3

The micro-costing study of each individual test was based on a combination of existing hospital costs and original data collection. For each test, direct and indirect costs as well as overhead costs were calculated. This involved building an understanding of the typical process of conducting a diagnostic test as well as the associated level of direct resource input regarding the level of direct staff input based on the staff grade and time spent on the key tasks within a standard procedure, any relevant consumables, e.g. drugs and ECG electrodes, and the equipment used. Five cost components were identified (*Figure 1*): (i) labour (direct pay costs). A 21% on-cost was added to reflect national insurance and superannuation contributions, unless otherwise stated. (ii) Materials and disposables (direct non-pay costs). (iii) Departmental overheads (indirect departmental costs). (iv) Capital equipment costs including direct clinical equipment such as machinery (e.g. the ECG machine, CT scan, etc.). To understand depreciation and maintenance costs, the following formula was used: average cost per test = annual depreciation or maintenance cost/total no. of tests per annum. (v) Corporate overhead costs were added based on the current level of contribution required within the hospital, which according to the selected hospital finance department was 30%. This contribution covered the rates, rents, and other corporate functions such as finance, human resources, and information technology, and was

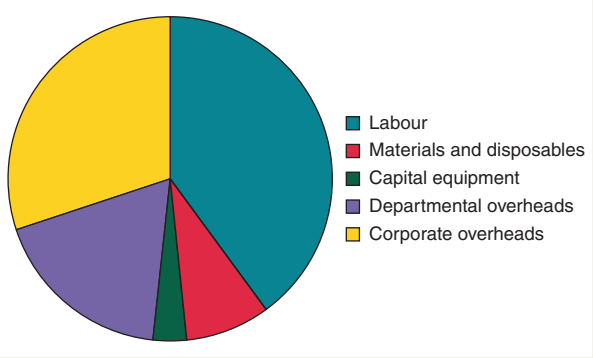

Figure 1 The five cost components of a diagnostic test are shown using the example of a standard ECG.

comparable to the percentage of other NHS hospitals. The cost of MRI/CT was calculated as half the sum of an MRI and a CT, since the study data did not differentiate between the two and we do not know the proportion of MRI and CT.

Results

Patient demographics, concomitant diseases, and the first and last specialist who were visited before the ILR implant are presented in *Table 2*. As many as 70% of the patients had been hospitalized for syncope, 36% had suffered severe trauma defined as fracture and/or bleeding.

Median and mean costs of tests per patient

The total number of tests performed per patient is shown in *Figure 2A* and *B*. As shown in the box plot and histogram, there is a lot of variation in the number of tests per patient and some patients received a large number of tests. In fact, as many as 25% of the patients underwent more than 20 tests, whereas 10% had more than 31 tests done.

The distribution of the costs per patient mirrors the findings from the distribution of tests performed (*Figure 3*). Analogously to the test data, the costs per patient varies a lot, and the medial 50% of the data is in the range of £569–£2246. The median costs of diagnostic tests per patient were £1114 (95% CI £995–£1233), while the mean expenditure per patient was substantially higher with £1613 (95% CI £1494–£1732). The costs for the most expensive 10% of the patients exceeded £3539 per patient.

Appropriate testing or not?

Since all patients had unexplained syncope at the time of the ILR implant, the diagnostic yield of any test performed before that was zero. *Table 1* summarizes the percentage of syncope patients who underwent the different diagnostic tests at least once. The most commonly prescribed tests were a 12-lead ECG 98%, echocardiography 86%, and basic laboratory tests 86%. The five most commonly performed tests are all included in the initial evaluation according to the guidelines. Other tests included in the initial evaluation were orthostatic blood pressure movements (48%), carotid sinus massage (36%), tilt test (35%), and external loop recording (12%). However, tests that did not belong to the initial evaluation were also commonly used, e.g. exercise test (52%), MRI or CT scan (47%), neurological or psychiatric evaluation (47%), and EEG (39%). The highest costs per test were related to electrophysiology testing with £1391 per test (the weighted cost in PICTURE was £348, since 25% of patients underwent the test), followed by coronary angiography with £1285 (weighted cost £296, 23%) and electroencephalography with £180 (weighted cost £70, 39%).

Neurological investigations were common, which may be explained by the fact that a neurologist or a psychiatrist was frequently consulted as the first specialist. Eleven per cent of patients were referred to a neurologist as their first specialist, and in total 47% had seen a neurologist before the ILR implant. Probably as a consequence, neurological tests, such as EEG (39%) and MRI/CT (47%), were commonly prescribed, also in what the investigators described as early in the investigation. In the current guidelines, such investigations are only recommended when non-syncopal transient loss of consciousness (T-LOC) is suspected, most importantly when epilepsy is a likely or possible reason. Similarly, the number of patients undergoing more than one EEG and/or MRI/CT was high (*Figure 4*).

Contribution of repeated testing to the cost per patient

Some tests were repeated many times, meaning that sometimes even inexpensive tests, such as an ECG, contributed significantly to the costs. For example, a standard ECG and a Holter recording were very frequently repeated, and this was also the case with more expensive tests, e.g. exercise testing and tests that could be related to the frequent visits to neurologists (*Figure 4*). The pyramide plots in *Figure 4* show how often the tests were performed and whether they were performed early or late. Considering the complicated care pathway for many patients, we may assume that more than one physician contributed when tests were repeated.

The diagnostic evaluation in PICTURE in relation to guideline recommendations

Since the study was entirely observational, there was nothing in the protocol or the case record forms to inform or guide the investigator about the current (2004) guidelines. However, the investigator was asked to indicate, by ticking a box, whether the implant, in his/her view, was performed 'in an initial phase of diagnostic work-up of syncope', i.e. early, or 'after full evaluation of the mechanism of syncope', i.e. late. The investigators classified 22.5% of the patients as having an early implant, whereas 67.7% had a late implant and the time-point was missing in 9.8% of the 570 patients. After the completion of the study, the early implants were compared with what the current guidelines included in the initial evaluation. We found that the proportion of patients who only had tests within the recommended initial evaluation was low, 12%, while there were many examples of over-investigation (*Figure 5*). The mean cost of diagnostic tests per patient in these 12% of patients was £709 compared with £1113 (95% CI £995–£1232) in the entire study population.

Cost of the implantable loop recorder and the implant procedure

The UK reference costs are the best available proxy of the true costs of an ILR implant, and in 2009–10 the associated reference costs

Table 2 Patient demographics

	All patients (*N* = 570)	Early implant (*N* = 128)	Late implant (*N* = 386)
Clinical features of syncope			
Hospitalized because of syncope	370 (70.0%)	68 (53.1%)	291 (75.4%)
Any severe trauma (fractures, haemorrhage, etc.)	204 (35.8%)	29 (22.7%)	151 (39.1%)
Clinical features of last episode			
Position at the beginning of the episode			
Supine	52 (9.0%)	12 (9.4%)	37 (9.6%)
Sitting	154 (27.0%)	28 (21.9%)	108 (28.0%)
Standing	274 (48.0%)	56 (43.8%)	192 (49.7%)
Unknown	83 (15.0%)	29 (22.7%)	45 (11.7%)
Activity at the beginning of the episode			
Rest	294 (52.0%)	42 (32.8%)	223 (57.8%)
During effort	144 (25.0%)	44 (34.4%)	89 (23.1%)
After effort	28 (5.0%)	7 (5.5%)	15 (3.9%)
Unknown	97 (17.0%)	34 (26.6%)	53 (13.7%)
Symptoms during the episode			
Muscle spasms (one sided)	8 (1.4%)	4 (3.1%)	2 (0.5%)
Muscle spasms (two sided)	19 (3.3%)	4 (3.1%)	15 (3.9%)
Grand mal	10 (1.8%)	2 (1.6%)	2 (1.3%)
Other muscle spasms	14 (2.5%)	2 (1.6%)	10 (2.6%)
Transpiration	73 (12.8%)	19 (14.8%)	47 (12.2%)
Cyanosis	19 (3.3%)	1 (0.8%)	13 (3.4%)
Angina pectoris	23 (4.0%)	5 (3.9%)	14 (3.6%)
Palpitations	76 (13.3%)	21 (16.4%)	49 (12.7%)
Dizziness	163 (28.6%)	56 (43.8%)	93 (24.1%)
Dyspnoea	33 (5.8%)	6 (4.7%)	24 (6.2%)
Fatigue	95 (16.7%)	21 (16.4%)	65 (16.8%)
Comorbidity			
Hypertension	277 (48.6%)	57 (44.5%)	187 (48.4%)
Diabetes	84 (14.7%)	16 (12.5%)	61 (15.8%)
Parkinson disease	2 (0.4%)	1 (0.8%)	1 (0.3%)
Transient ischaemic attack (TIA)	20 (3.5%)	6 (4.7%)	11 (2.8%)
Stroke	37(6.5%)	5 (3.9%)	25 (6.5%)
Other neurological disorder	36 (6.3%)	4 (3.1%)	16 (4.1%)
Structural heart disease			
Cardiomyopathy	18 (3.2%)	2 (1.6%)	12 (3.1%)
Valvular heart disease	30 (5.2%)	5 (3.9%)	24 (6.2%)
Coronary artery disease	84 (14.7%)	16 (12.5%)	62 (16.1%)
Other	29 (5.1%)	4 (3.1%)	18 (4.7%)
Care pathway			
Profession of first consulted specialist hospital (*n*, %)			
Cardiologist	232 (41.0%)	67 (52.3%)	151 (39.1%)
Electrophysiologist	12 (2.0%)	3 (2.3%)	9 (2.3%)
Cardiothoracic surgeon	1 (0%)	0 (0.0%)	1 (0.3%)
Specialist for internal diseases	100 (18.0%)	12 (9.4%)	78 (20.2%)
Emergency medicine	133 (23%)	24 (18.8%)	95 (24.6%)
Imaging and radiologist	3 (1%)	1 (0.8%)	2 (0.5%)
Neurologist	63 (11.0%)	14 (10.9%)	35 (9.1%)
All specialists seen in relation to syncope			
General practitioner	357 (62.6%)	68 (53.1%)	255 (66.1%)
Cardiologist	521 (91.4%)	121 (94.5%)	348 (90.2%)
Electrophysiologist	166 (29.1%)	25 (19.5%)	132 (34.2%)

Continued

Table 2 *Continued*

	All patients ($N = 570$)	Early implant ($N = 128$)	Late implant ($N = 386$)
Cardiothoracic surgeon	3 (0.5%)	0 (0%)	3 (0.8%)
Specialist for internal diseases	214 (37.5%)	27 (21.1%)	159 (41.2%)
Emergency medicine	207 (36.3%)	40 (31.3%)	145 (37.6%)
Imaging and Radiologist	104 (18.2%)	14 (10.9%)	72 (18.7%)
Neurologist	270 (47.7%)	41 (32.0%)	192 (49.7%)
Last referral			
General practitioner	47 (8.2%)	12 (9.4%)	29 (7.5%)
Cardiologist	346 (60.7%)	90 (70.3%)	225 (58.3%)
Electrophysiologist	64 (11.2%)	13 (10.2%)	49 (12.7%)
Cardiothoracic surgeon	1 (0.2%)	0 (0.0%)	1 (0.3%)
Specialist for internal diseases	50 (8.8%)	5 (3.9%)	41 (10.6%)
Emergency medicine	27 (4.7%)	8 (6.3%)	13 (3.4%)
Imaging and Radiologist	2 (0.4%)	0 (0%)	1 (0.3%)
Neurologist	23 (4.0%)	0 (0%)	18 (4.7%)

The classification 'early implant' vs. 'late implant' was according to the investigators' assessment. In 56 patients, these data were missing.

were £2606 (HRG EA03Z), including the device and all procedure costs and overheads such as staffing, catheterization laboratory utilization, disposable material, and hospital bed costs.

Discussion

The cost of investigation in patients with unexplained syncope varied greatly due to the number and type of tests performed per patient before the ILR implant. While some patients underwent many tests, which were often repeated, other patients received relatively little testing. The expenditure for some patients seems far too high, which most probably mainly reflects the lack of a structured care pathway. In this strictly observational registry, only 12% of the patients received tests entirely within the guideline recommendations for initial investigation before receiving the ILR, which is a very important finding, since it implies that the messages and recommendations of current guidelines are not known or at least not followed.

Economic impact of unstructured vs. structured care pathways

Although several previous reports agree that the economic impact of syncope management is substantial,[1,3,9] the approaches and suggested solutions for reducing costs have varied. The creation of structured care pathways, inside or outside specific multidisciplinary syncope units, may lead to a uniform management according to pre-set guidelines[8,13–15] and/or improved diagnostic and treatment algorithms.[9] Specifically, approaches leading to fewer hospitalizations may be cost-effective[16] as well as those leading to the appropriate use of available tests, avoiding both over- and under-investigations.

What is an adequate care pathway and an adequate use of diagnostic tests?

Overuse of diagnostic tests puts a burden on healthcare costs, but a prolonged and unsuccessful series of visits and diagnostic tests also cause patient frustration. Considering that arrhythmias are common causes in patients with unexplained syncope, an ILR implant early after the initial evaluation has been found a reasonable approach. Continuous ECG monitoring has a high chance of providing a symptom vs. rhythm correlation during the next syncope recurrence, which is crucial for determining the mechanism and guide subsequent appropriate treatment. The diagnostic tests of the initial evaluation of unselected syncope,[4,5] including a standard ECG, echocardiography, carotid sinus massage in patients older than 40 years, and orthostatic blood pressure challenge, aim at identifying the most common causes of syncope, while those who remain undiagnosed after the initial evaluation may be defined as unexplained. In a clinical study, based on guidelines only 12% of unexplained syncope patients received an EEG and 14% a head CT.[17]

While patients with unexplained syncope are more likely to have an underlying arrhythmia mechanism than unselected patients with syncope, arrhythmias causing syncope may occur at varying and often long intervals, giving standard ECGs and short-lasting ECG monitoring little chance of providing symptoms vs. ECG correlation when compared with continuous long-term ECG monitoring.[18] Nevertheless, Holter monitoring was a very frequently used and often repeated test in PICTURE patients before the decision to implant an ILR, thus representing an inadequate use of available diagnostic tests. An earlier ILR implant rather than repetition of already non-diagnostic tests would seem more reasonable and is consistent with the current guidelines,[5] with a good chance of being cost-effective in comparison with unstructured conventional testing.[19]

Tests such as neurological evaluation or blood tests are only indicated when there is suspicion of non-syncope T-LOC, but are nevertheless often prescribed, also very early in the evaluation, the former probably because the symptoms frequently include various signs of convulsions. When described to the physician after the event, these symptoms might sound alarming enough to lead the early evaluation in a neurological direction, perhaps aiming to exclude or in some cases with the hope of confirming a neurological

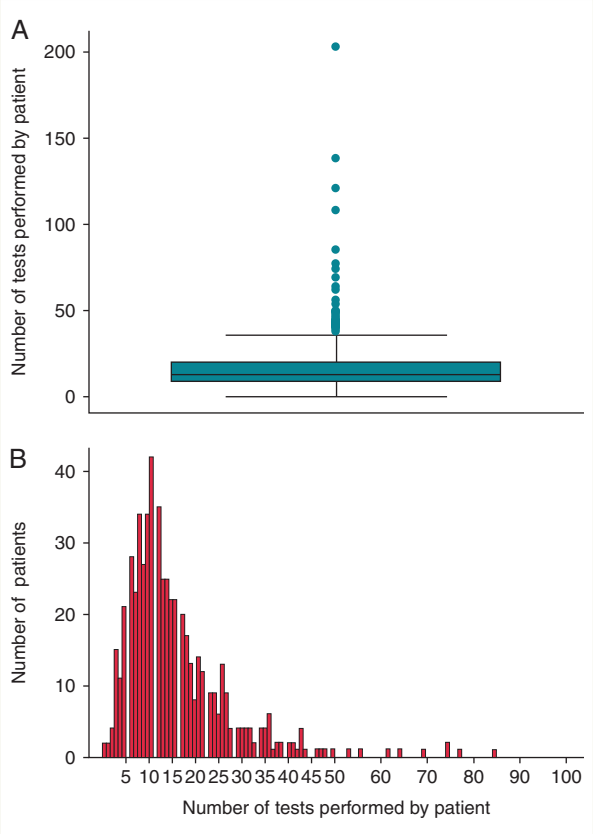

Figure 2 The tests performed per patient. (*A*) The box shows the IQR and that the middle 50% of the patients had between 9 and 20 tests. The line inside the box defines the median number of tests (13). The line is below the middle of the box illustrating that the median is smaller than the mean (17). The whiskers around the box are drawn at 1.5 times the IQR, with the upper whisker at 36.5 tests. The black dots outside the whiskers are considered as outliers. The box plot illustrates that many patients received far more than the median number of tests. (*B*) The histogram shows the tests performed by patient in more detail. Note that patients who had more than 100 tests are only shown in the box plot.

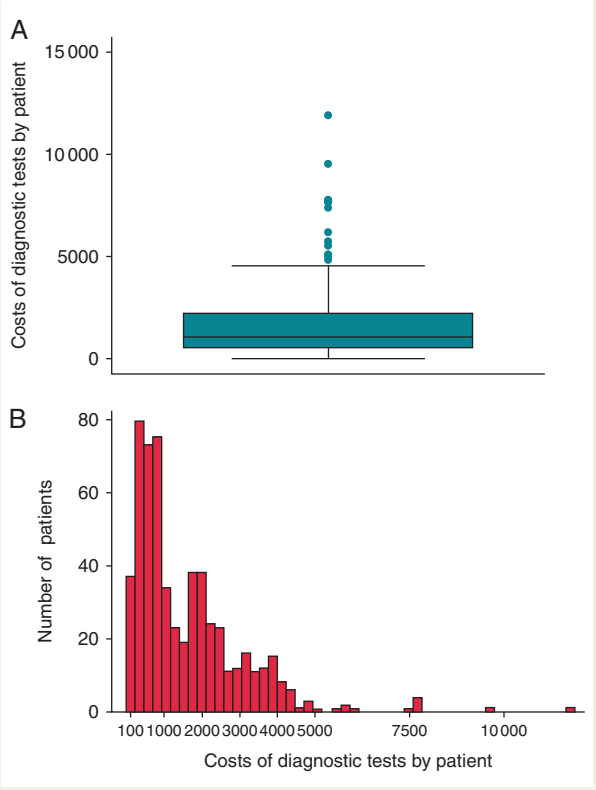

Figure 3 The total costs of diagnostic tests per patient. (*A*) The distribution of the total costs shows high costs for a substantial share of patients. The median (£1114) is much smaller than the mean costs of tests (£1613). The box shows the IQR of £569–£2246. All costs above the upper whisker of £4762 are considered outliers. (*B*) The histogram shows the distribution of total costs per patient in more detail and illustrates the significant costs incurred for patients in whom a large number of tests were done. In the most expensive, 10% of patients the cost exceeded £3539 per patient.

cause, e.g. epilepsy. However, convulsions are common in syncope and the underlying mechanism is more likely to be clarified by symptom vs. ECG monitoring than with neurological tests. This likeliness increases in patients defined as having unexplained syncope. In studies using an ILR in unexplained syncope, ~80% of the diagnostic yield was based on arrhythmias, including both brady- and tachycardias, that needed very different subsequent treatments.[10,20] In contrast, the diagnostic yield using conventional diagnostic tests was only 12.5%.[20]

Can better adherence to guidelines influence the microeconomics of investigation of unexplained syncope?

In the 2004 version of the guidelines on the management of syncope, the implant of an ILR was presented as an option after an initial evaluation. Patients who had an early implant as defined by the investigators were most often more extensively investigated than recommended in the guidelines, but there was a significant difference as opposed to what the investigators regarded as a late implant. The observation that the diagnostic yield was similar supports that less investigation and lower costs for diagnostic tests before an earlier ILR implant can be achieved without losing diagnostic yield.

Possible effects of inadequate testing on other drivers of cost in unexplained syncope

Patients in PICTURE had had a median of four syncope events during a median of 2 years before their ILR implant. During this period, 70% were at some time hospitalized for syncope and 36% suffered severe trauma with fracture and/or bleeding. A long time between the first healthcare contact and diagnosis may reasonably increase the risk of recurrent syncope and syncope-related hospitalization and trauma.

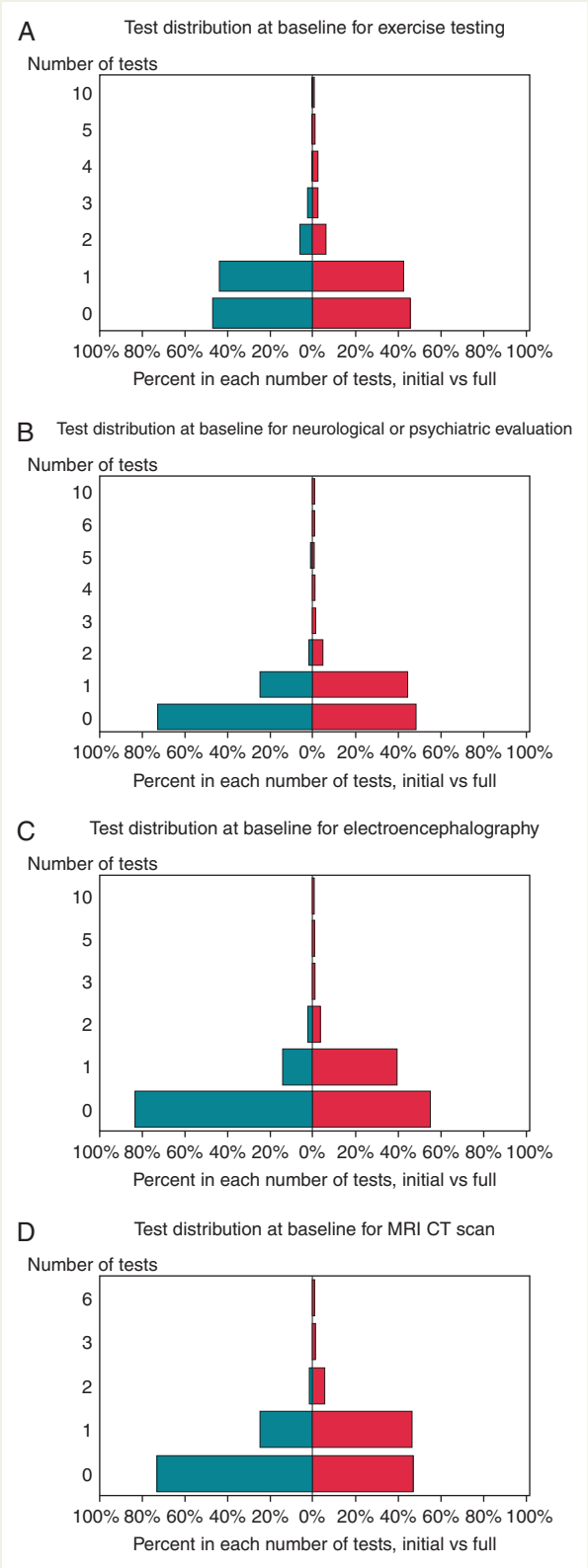

Figure 4 The pyramide plots demonstrate that tests were often repeated and show how often they were prescribed early (to the left of the middle line) and late (to the right of the middle line) evaluation as judged by the investigators. (*A*) Exercise test; (*B*) neurological and/or psychiatric evaluation; (*C*) electroencephalography; and (*D*) MRI or CT scan.

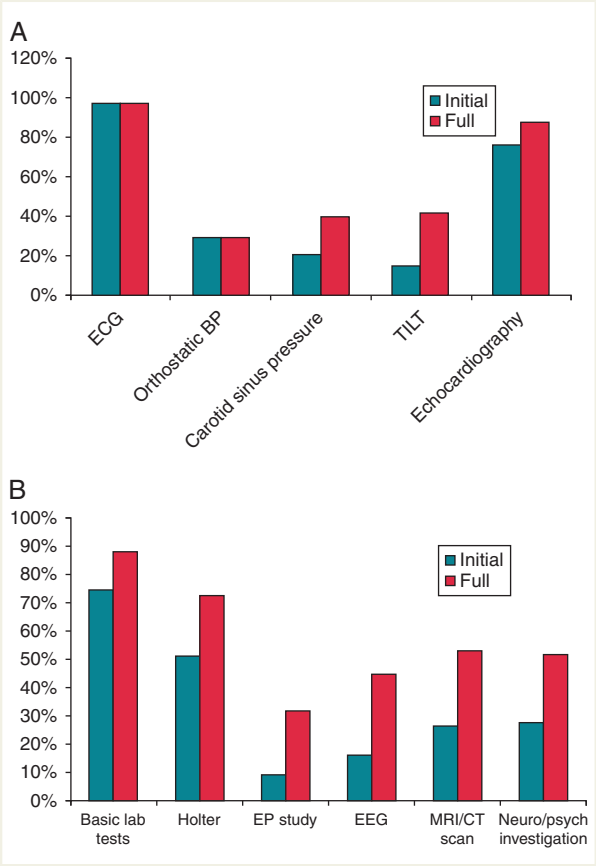

Figure 5 Some of the tests that are recommended in the guidelines in the (*A*) initial and the (*B*) extended evaluation of syncope. While several tests of the initial evaluation were performed much less often than recommended, some more specific tests were performed more often and more early than recommended.

An adequate investigation should ideally result in a correlation of symptoms vs. ECG. This is equally important in patients with and without an arrhythmia mechanism. While brady- and tachyarrhythmias have their specific treatment, patients with syncope during sinus rhythm, e.g. with psychogenic syncope, are also an important subgroup that will benefit from a correct diagnosis and information, which can subsequently help them to manage without further visits to healthcare facilities.

Cost of the implantable loop recorder and the implant procedure

As shown in our analysis of the PICTURE study, the frequent repetition of tests and the use of specific tests early in the investigation was a poor use of healthcare resources as they did not result in a diagnosis. At the same time, ILRs have been shown to be cost-effective in patients with unexplained syncope,[19] implying that the higher initial costs should not discourage physicians from using an ILR when it is an option according to the current guidelines. In addition, a miniaturized ILR has recently become available, the Reveal LINQ, and due to its much smaller size a new insertion technique has made the implant procedure minimally invasive.[21] As a consequence, this minimally

invasive procedure can be performed also in settings outside the catheterization laboratory, thus offering possibilities to reduce the procedure costs.

Limitations

We used UK data from 2010 to 2011 for reference. The cost level and reimbursement system may vary between countries and regions, but the relative difference in cost between tests is likely to be similar, which should make it possible to substitute our cost figures for other currencies to get valid estimations. The selected university hospital may not reflect other hospitals in all test procedures for unexplained syncope.

In addition, there is significant variation in the costs of treating individual patients, which is not reflected in this study. The times required for procedures, the grade of staff that usually administers the procedure, and the usual pathway were overall averages, gained from speaking to clinical staff either at the selected hospital, or where not available, from other UK hospitals. Again, these are likely to vary from patient to patient and from physician to physician.

Conclusions

This analysis of the microeconomics of the use of diagnostic tests in the PICTURE registry identified significant over-investigation in terms of both number and types of tests, especially in the initial phase of the evaluation. As a consequence, the analysis identified important opportunities to reduce test-related costs before an ILR implant by more appropriate use of tests recommended in the initial evaluation, by reducing frequent repetition of the same tests, and by avoiding early use of specific and expensive tests usually performed only on specific suspicions about the underlying mechanism. A structured multidisciplinary approach would have the best prerequisites to achieve an optimal result.

Conflict of interest: N.E. and N.J.L. are members of the Medtronic Speaker Bureau; C.W., S.T., and G.R. are employees of Medtronic.

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References

1. Sutton R, Benditt DG. Epidemiology and economic impact of cardiac syncope in western countries. *Future Cardiol* 2012;**8**:467–72.
2. Shiyovich A, Munchak I, Zehlingher J, Grosbard A, Katz A. Admission for syncope: evaluation, cost and prognosis according to etiology. *IMAJ* 2008;**10**:104–8.
3. Malasana G, Brignole M, Daccarett M, Sherwood R, Hamdan MH. The prevalence and cost of the faint and fall problem in the state of Utah. *PACE* 2011;**34**:278–83.
4. Brignole M, Alboni P, Benditt DG, Bergfeldt L, Blanc JJ, Bloch Thomsen PE *et al.* Guidelines on management (diagnosis and treatment) of syncope—update 2004. *Europace* 2004;**6**:467–537.
5. Moya A, Sutton R, Ammirati F, Blanc JJ, Brignole M, Dahm JB *et al.* Guidelines for the diagnosis and management of syncope (version 2009). *Eur Heart J* 2009;**30**:2631–71.
6. National Institute for Health and Clinical Excellence. *Transient Loss of Consciousness ('Blackouts') Management in Adults and Young People. NICE Clinical Guideline 109*. London: NICE, 2010. http://guidance.nice.org.uk/CG109/NICEGuidance/pdf/English (29 Nov 2010, date last accessed).
7. O'Dwyer C, Hade D, Fan CW, Cunnigham C, Kenny RA. How well are European Society of cardiology (ESC) guidelines adhered to in patients with syncope? *Ir Med J* 2010;**103**:11–4.
8. Ammirati F, Colaceci R, Cesario A, Strano S, Della Scala A, Colangelo I. Management of syncope: clinical and economic impact of a Syncope Unit. *Europace* 2008;**10**:471–6.
9. Sun BC. Quality-of-life, health service use, and costs associated with syncope. *Prog Cardiovasc Dis* 2013;**55**:370–5.
10. Edvardsson N, Frykman V, van Mechelen R, Mitro P, Mohii-Oskarsson A, Pasquié J-L *et al.* Use of an implantable loop recorder to increase the diagnostic yield in unexplained syncope: results from the PICTURE registry. *Europace* 2010;**13**:262–9.
11. Linker NJ, Voulgaraki D, Garutti C, Rieger G, Edvardsson N. PICTURE Study Investigators. Early versus delayed implantation of a loop recorder in patients with unexplained syncope —effects on care pathway and diagnostic yield. *Int J Cardiol* 2013;**170**:146–51.
12. Edvardsson N, Garutti C, Rieger G, Linker NJ, for the PICTURE Study Investigators. Unexplained syncope: implications of age and gender on patient characteristics and evaluation, the diagnostic yield of an implantable loop recorder, and the subsequent treatment. *Clin Cardiol* 2014;**37**:618–25.
13. Brignole M, Ungar A, Casagranda I, Giulizia M, Lunati M, Ammirati F *et al.* Prospective multicenter systematic guideline-based management of patients referred to the syncope units of general hospitals. *Europace* 2010;**12**:109–18.
14. Shen WK, Traub SJ, Decker WW. Syncope management unit: evolution of the concept and practice implementation. *Prog Cardiovasc Dis* 2013;**55**:382–9.
15. Sanders NA, Jetter TL, Brignole M, Hamdan MH. Standardized care pathway versus conventional approach in the management of patients presenting with faint at the University of Utah. *Pacing Clin Electrophysiol* 2013;**36**:156–62.
16. Shin TG, Kim JS, Song HG, Jo IJ, Sim MS, Park SJ. Standardized approaches to syncope evaluation for reducing hospital admissions and costs in overcrowded emergency departments. *Yonsei Med J* 2013;**54**:1110–8.
17. van Dijk N, Boer KR, Colman N, Bakker A, Stam J, Van Grieken JJ *et al.* High diagnostic yield and accuracy of history, physical examination, and ECG in patients with transient loss of consciousness in FAST: the Fainting Assessment study. *J Cardiovasc Electrophysiol* 2008;**19**:48–55.
18. Kühne M, Schaer B, Moulay N, Sticherling C, Osswald S. Holter monitoring for syncope: diagnostic yield in different patient groups and impact of device implantation. *Q J Med* 2007;**100**:771–7.
19. Davis S, Westby M, Pitcher D, Petkar S. Implantable loop recorders are cost-effective when used to investigate transient loss of consciousness which is either suspected to be arrhythmic or remains unsuspected. *Europace* 2012;**14**:402–9.
20. Farwell DJ, Freemantle N, Sulke N. The clinical impact of implantable loop recorders in patients with syncope. *Eur Heart J* 2006;**27**:351–6.
21. Tomson T-T, Passman R. The reveal LINQ insertable cardiac monitor. *Expert Rev Med Devices* 2014;**12**:7–18.