Cost comparison of two implantable cardiac monitors in two different settings: Reveal XT in a catheterization laboratory vx. Reveal LINQ in a procedure room

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Cost comparison of two implantable cardiac monitors in two different settings: Reveal XT in a catheterization laboratory vs. Reveal LINQ in a procedure room

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Aims Implantable cardiac monitors (ICMs) are used for long-term heart rhythm monitoring, e.g. to diagnose unexplained syncope or for detection of suspected atrial and ventricular arrhythmias. The newest ICM, Reveal LINQ™ (Medtronic Inc.), is miniaturized and inserted with a specific insertion tool kit. The procedure is therefore minimally invasive and can be moved from catheterization laboratory (cath lab) to a less resource intensive setting. This study aims to assess the change in procedure costs when performed outside the cath lab.

Methods and results A bottom-up costing methodology was used. Data were collected from interviews with physicians, cath lab managers, and financial controllers. Hospitals in the Netherlands, France, and the UK were included in this study. The cost comparison of a Reveal XT implantation in a cath lab setting vs. a Reveal LINQ insertion outside a cath lab resulted in an estimated reduction of €662 for the UK, €682 for the Netherlands, and €781 for France. These cost savings were primarily realized through fewer staff, less equipment, and overhead costs. The net effect on savings depends on the price differential between these two technologies. The patient care pathway can be improved due to the possibility to move the procedure out of the cath lab.

Conclusion Inserting the miniaturized version of the ICM is simpler and faster, and the procedure can take place outside the cath lab in a less resource intensive environment. Hospitals save resources when the higher price of the Reveal LINQ does not outweigh these savings.

Keywords Implantable cardiac monitor • Costs • Catheterization laboratory • Procedure room • Syncope

Introduction

Improvements in technology can change clinical practice and may lead to a more efficient use of healthcare resources. This study assesses changes in hospital practice and resource use as a result of a new miniaturized implantable cardiac monitor [ICM; also called Implantable Loop Recoder (ILR)]. Implantable cardiac monitors are widely used for detection of suspected arrhythmia. Information is stored in its circular memory as electrocardiograms (ECGs) and can be reviewed later. Implantable cardiac monitors are well established in clinical guidelines and clinical practice for the diagnosis of unexplained syncope.[1–6] The rate of patients with recurrent syncope that remains unexplained varies between 5 and 20%, the most common rate is 18%.[7–11] If diagnostic testing during the syncope investigation does not result in a diagnosis, prolonged ECG monitoring is the main tool for diagnosing a cardiac cause of syncope. Detection of arrhythmias, the most common cardiac causes of syncope, is important, because of the associated mortality

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What's new?

- This study documents that miniaturization of technology saves hospital resources.
- The insertion of a miniaturized cardiac monitor is simpler and faster than the implantation of the previous version.
- Owing to the miniaturized size and specifically designed insertion kit, the procedure no longer needs to take place in a cath lab, but can be performed in a less resource intensive setting.
- The procedural efficiencies and change in implant location lead to cost savings; the net cost savings depend on the prices of the two devices.
- The patient care pathway is improved since waiting time for the device can be reduced as well as waiting time during the day of procedure.

risk.[12] Implantable cardiac monitors have increasingly been used for the clinical evaluation of unexplained syncope in the last decade as they were shown to have a high diagnostic yield and shortened the time to diagnosis.[13] The diagnostic yield of ICM in unexplained syncope has been shown to be between 43 and 52% while conventional tests have a diagnostic yield of 6–20%.[14,15] While ICMs are mostly used for the indication of syncope, some ICMs have the additional function to detect atrial fibrillation (AF) and are used in primary and secondary stroke prevention and for monitoring AF after an ablation.[16–21]

Different devices from various companies are available on the market.[22] The recently developed Reveal LINQ™ (Medtronic, Tolochenaz, Switzerland) is the smallest device currently available; it is 88% smaller in volume than the previous ICM model Reveal® XT. Owing to the miniaturization of the device and a specifically developed insertion kit, the procedure is minimally invasive. This means that the procedure can be moved out of the catheterization laboratory (cath lab) or electrophysiology (EP) lab to a less resource intensive setting.[23] An alternative location could be a standard clinical examination room, where minor surgical procedures are performed (called a procedure room in this study).

The insertion of Reveal LINQ has been shown to be simpler and faster than the implantation of other ICMs[24] and the procedure can be moved out of the cath lab, which might result in costs savings from less staff time and lower room-related costs.

In this study, we compare the procedure and associated costs of inserting Reveal LINQ in a procedure room to implanting its predecessor, Reveal XT, in a cath lab or EP lab. Hospitals can use the results of this study to estimate the change in costs from switching implant location.

Methods

A bottom-up costing methodology was used in this cost comparison study. Data were collected from semi-structured interviews with experienced implanters (six physicians and two nurses), cath lab managers and financial departments. Implanters were asked to describe the patient care pathway as well as the procedure with respect to time required by members of staff and resource utilization (instruments, materials, and medication) during the time the procedure room was occupied. Cath lab managers were asked to provide details on the equipment and organization of the cath lab (cath lab occupancy, turn-around cycle, and cath lab case load). Finally, the financial department was asked to provide costs of personnel, equipment, medication, disposable materials, and overhead. Data on the procedure costs in a cath lab as well as the expected costs of the Reveal LINQ procedure in the procedure room were collected. Physicians had performed or otherwise witnessed a limited number of insertions with the Reveal LINQ since the device was launched in early 2014. Interviews were generally conducted on site, or if not otherwise possible by phone. Respondents received the questions in advance of the interview.

Labour costs were based on the time required to do one procedure, multiplied by relevant gross salary costs (i.e. including benefits and prior to any deductions for taxes, social security, and health insurance). In addition, a mark-up for indirect time (e.g. administrative activities) was applied. Costs for equipment were based on depreciation costs, which refers to the purchase price of equipment divided by the equipment's life span, corrected for interest rate. The depreciation costs were calculated per minute, based on the occupancy of the room, and multiplied by the procedure time. All equipment in the room was included in the cost estimate, even if the equipment was not used during the procedure, as the equipment could not be used for other purposes during this time. Medication use was multiplied by medication costs, which were derived from the financial departments. The number of disposables was recorded per procedure, and multiplied by purchase price, to obtain total costs for disposables per procedure. Three different methods to calculate overhead costs were applied depending on data availability. Finance departments were first asked whether they could provide the total overhead costs for the cath lab and the procedure room. If these costs were not available, they were asked to provide the total overhead costs of the hospital. These hospital overhead costs were attributed to the cath lab and the procedure room according to redistribution factors (i.e. square metres, full time equivalents, material usage, and depreciation of equipment) provided by hospitals. In these two methods, procedure time was used to attribute total overhead costs of the room to one procedure. If neither the cath lab/procedure room overheads, nor the general overhead costs were available, a general mark-up of 40% was applied on direct costs. This mark-up percentage was derived from the Dutch costing manual,[25] which is based on detailed costing research in 84 general Dutch hospitals. As costs for cleaning the cath labs and procedure rooms are reported separately in our study, this mark-up (40%) is slightly lower than reported in the costing manual (42%).

Data on volume and costs were collected in hospitals in the Netherlands (three hospitals), France (two hospitals), and the UK (two hospitals). We interviewed eight physicians, five cath lab managers, and five hospital employees from finance departments. On an average, each hospital implanted 63 (range of 48–80) ICMs per year, sometimes from different manufacturers.

A translator was present for the interviews with finance departments and cath lab managers in France. Costs are expressed in Euros; an exchange rate of 1GBP = 1.2190 EUR was used to convert costs from the UK. No correction for differences in purchasing powers was applied; a Euro in France and the Netherlands was valued equally.

Results

In the following, we first describe the different patient care pathways for the two procedures and subsequently the costs. For the Reveal XT procedure, patients are admitted to a day-care ward at the hospital on the day of the procedure, except for France where

some patients are admitted the night before the procedure when the procedure is scheduled for the next morning. The procedure is performed in a cath lab. For each procedure, the cath lab is scheduled for ~60 min, including preparation of the cath lab, the procedure and cleaning of the cath lab. After that, patients return to the day-care ward, where they recover from the procedure. Patients do not necessarily need to be admitted to the day-care ward in the hospital for the Reveal LINQ implant; in some centres, patients directly report to the procedure room at the scheduled time of the procedure and leave the hospital directly afterwards.

Figure 1 describes the patient care pathway for both procedures in a flow chart. The room occupancy is shorter for the Reveal LINQ (55 min). Similarly, the procedure time (skin-to-skin; 9.4 min) is shorter due to the new insertion technique and the resulting ease in placing the device and closing the wound. In addition, waiting time for the implant (the time between decision of implant and the implant itself) can be reduced when the Reveal LINQ is inserted in a procedure room, since waiting lists for procedure rooms are shorter than for cath labs.

Table 1 shows the medical personnel involved and their time spent for one procedure. Implanting the Reveal LINQ would be less time consuming; a time saving of 5–10 min was anticipated. Physicians from the UK stated that less-qualified personnel could perform the procedure; cardiologists in training may replace cardiologists to perform the insertion.

All physicians used lidocaine (varying dosages) during the implant of Reveal XT and would also use this for Reveal LINQ. For Reveal LINQ, no flucloxacillin would be given to patients, whereas currently one of three physicians provides patients with this antibiotic for an implant. Owing to the insertion kit developed for the new device, the usage of disposable materials will also decrease; more specifically less bandages and sutures will be used.

Generally, ICMs are still implanted in cath labs or EP labs. The equipment in a cath lab or an EP lab differed by hospital. *Table 2* shows the proportion of cath labs and EP labs in which various types of equipment were available. All cath labs and EP labs had X-ray equipment; EP labs also had imaging technology, but neither X-ray or imaging technology was used in the procedure. Since Reveal LINQ is minimally invasive, most physicians therefore anticipated that the procedure can be moved to a less sterile and less resource intensive setting. A possible location would be a procedure room, which is rather similar to a standard clinical examination room, sometimes equipped with air flow control. *Table 2* also shows the equipment typically present in a procedure room.

Costs

Table 3 presents the mean costs associated with the two procedures in the two different settings for the UK. Labour costs were lower for Reveal LINQ, owing to shorter preparation, procedure time, and reduced recovery time. In addition, physicians could be substituted by less-qualified, and hence, less costly personnel. The overall change in costs depends on the price difference between the Reveal LINQ system and Reveal XT.

Depreciation costs for instruments and equipment were considerably lower for a procedure room. In addition, cleaning costs were lower, as the procedure room was cleaned only once a day. *Table 3* presents the overhead costs calculated with a general mark-up, as overhead costs for the procedure room necessary for the alternative calculations for overhead costs were not readily available. Overhead costs were lower for the procedure room (€30) than for the cath lab (€197) using this method, as the direct costs used to determine overhead costs were lower. For the cath lab, data were available for all three methods of calculating overhead costs used in our study. When overhead costs of the cath lab were calculated as (i) the total cath lab overhead costs attributed to one procedure based on procedure time or (ii) total hospital overhead costs attributed to the cath lab according to redistribution factors (e.g. square metres and full time equivalent) and subsequently attributed to one

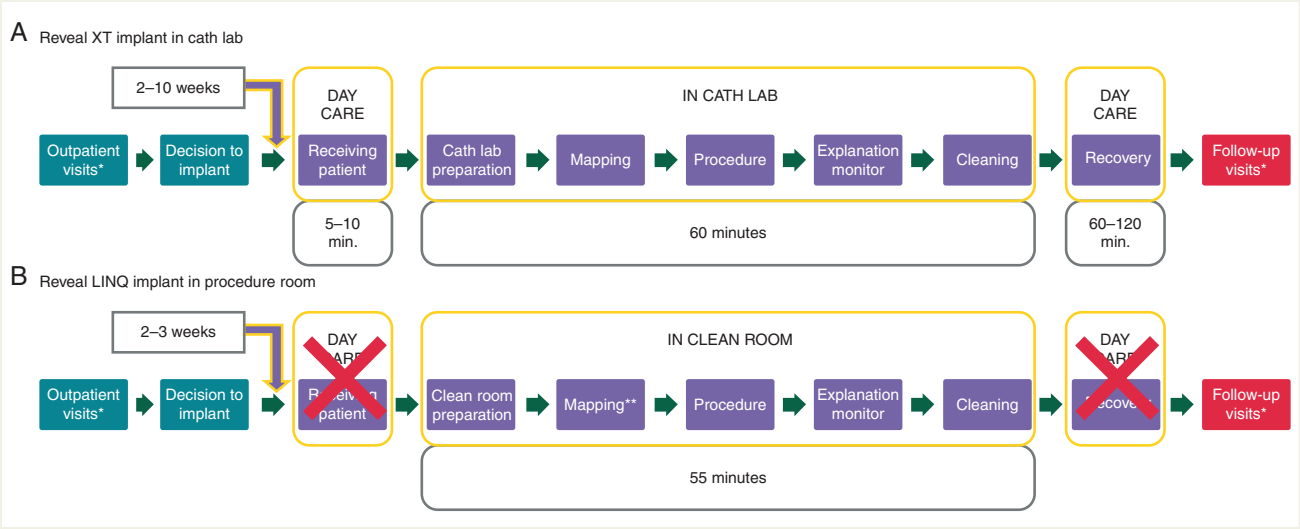

Figure 1 Flow chart of different steps in the process of implanting/inserting an ICM (hospital perspective). Turquoise boxes indicate pre-implant visits; liac boxes indicate steps during day of implant; red box indicates post-implant visits. *Number of visits depends on patient's complaints and response; **Whether mapping is performed prior to the procedure varies between hospitals and countries. Note: variations between countries and hospitals with regard to steps and timing exist.

Table 1 Medical personnel involved in procedure

	Proportion of procedures involved				Time spent if involved (min)			
	NL (%)	UK (%)	FR (%)	Overall (%)	NL	UK	FR	Overall
Reveal XT								
Cardiologist	67	75	100	79	21.3	20.6	20.0	23.1
Technician	100	100	0	71	49.2	36.9	–	44.3
Nurse	67	100	100	86	45.0	54.4	45.0	48.8
Radiographer	0	50	0	14	–	43.8	–	43.8
Cardiologist in training	0	25	0	7	–	15.0	–	30.0
Reveal LINQ								
Cardiologist	67	0	100	57	16.3	–	13.8	15.0
Technician	100	100	0	71	44.2	25.6	–	36.8
Nurse	67	100	100	86	40.0	43.1	36.3	39.8
Radiographer	0	0	0	0	–	–	–	–
Cardiologist in training	0	25	0	7	–	7.5	–	15.0

Table 2 Equipment available in cath lab, EP lab, and procedure room

	Cath lab (%)	EP lab (%)	Clean room (%)
IT Hardware	67	67	0
Diagnostic Review Station	67	33	0
Defibrillator	100	100	100
Patient Monitor	100	100	0
X-ray machine	100	100	0
Microcoagulation System	0	67	0
Intra-Aortic Balloon Pomp	33	33	0
Resuscitation System	0	33	0
Ventilation Monitor	33	67	0
Cardiac 3D Imaging System	0	67	0
Injector	33	50	0
Cardiac Measurement System	0	50	0
Cardiac Mapping System	0	67	0
Electrophysiology Study System	0	33	0
Cautery Machine	33	17	100
Equipment Storage	0	67	100
Lead Apron Pegs	33	50	0
Heart Navigator IT	0	50	0
Laminar Airflow Cabinet	0	17	0
Operation Lamp	33	33	100
Equipment Rack	0	50	100
Cabinet	33	50	0
Cardiograph Machine	0	50	0
Blood Pressure Metre	33	67	0
Oxygen Machine	33	67	0
Operation Table	33	67	100
Pressure Wire	33	33	0

Table 3 Costs associated with the Reveal XT and Reveal LINQ procedures in cath lab and procedure room, respectively

	Reveal XT in cath lab	Reveal LINQ in procedure room	Difference
Procedure-related costs			
Labour	€104	€42	−€63
Medication	€6	€2	−€4
Materials	€23	€20	−€3
Room-related costs			
Labour	€8	€7	−€1
Instruments/ equipment	€100	€5	−€95
Cleaning	€57	€4	−€53
Overhead costs			
Overhead costs	€197	€30	−€167
Hospital admission costs			
Hospital admission	€276	€0	−€276
Total costs difference			−€662

The net cost impact for hospital depends on the cost difference between the two devices.

procedure according to the procedure time, the differences in overhead costs between cath lab and clean room were similar to the differences calculated with the mark-up method. The mark-up method was therefore considered a valid method.

Additionally, cost savings were expected because patients do not necessarily need to be admitted to a day-care ward for the LINQ procedure. The price of the admission (€276) was based on the Dutch costing manual[25] (corrected for inflation), as hospital-specific

estimates were not available. The price of hospital admission from the costing manual did not include procedures or salary costs to avoid double counting. Costs for medication and materials were similar for both procedures. Overall, the savings from room and procedure amounted to €662; UK hospitals can save resources when they implant the Reveal LINQ technology in a procedure room when the price of this new device is not more than €662 higher than Reveal XT.

Country variations

With respect to the procedures, variations between countries were small. Physicians in all countries anticipated that it would be easier and quicker to do the Reveal LINQ insertion. Costs for the Netherlands and France are reported in Supplementary material online, *Appendix S1*. In the UK and the Netherlands, the Reveal LINQ procedure is already performed by a specially trained nurse, which translates into greater labour cost savings than in France; potential cost savings from reducing hospital admissions also varied between and within countries. The cost savings from reducing hospital admissions were highest in France. French hospitals can save resources when they implant the Reveal LINQ in a procedure room when the price of the new device is not more than €781 higher than the Reveal XT; Dutch hospitals save resources when the price difference is lower than €682.

Discussion

Improvements in technology can change clinical practice and patient care pathways and lead to a more efficient use of healthcare resources. This study assesses changes in hospital practice and resource use due to miniaturization of an ICM. We show that inserting the miniaturized Reveal LINQ system is simpler and faster than the previous ICM—Reveal XT. The procedure does no longer have to take place in a cath lab, but can be moved to a less resource intensive procedure room. These two aspects translate into cost savings (€662 in the UK, €682 in the Netherlands, and €781 in France); the net cost difference depends on the costs of the two devices.

However, lower costs are not the decisive factor for moving the procedure out of the cath lab, safety is most important. In our study, physicians stated that they do not expect differences in complication rates, such as local bleeding, skin irritation, and infections. Other incentives can also influence the choice of location, such as the need to meet cath lab occupancy rates, or a hospital's policy to promote the innovative nature of its organization.

The focus in this study was on comparing the costs of the two procedures. However, moving the procedure out of the cath lab potentially leads to organizational efficiency gains in a hospital. It might enable hospitals to optimize their cath lab since the freed-up cath lab time can be used for other, more complex procedures. As a result, waiting list for the cath lab could be reduced, although the total reduction depends on the absolute number of procedures performed. In addition, the simplified technology could be applied by a broader clinician base and cardiologist time is freed up for more complex procedures. Moreover, less staff time would be needed for the preparation and post care of the procedure. Moreover, the wireless data transmission capability of the Reveal LINQ could lead to savings in staff time when patients are monitored remotely, which has not been investigated yet in this study.

It has previously been shown that the miniaturization of the device and simplified procedure have increased physician and patient acceptance.[24] Miniaturized devices also provide important benefits to patients. Interviewees stated that thanks to the change in implant location, patient care pathways become more efficient since the time from implant decision to the actual implant can be reduced. In addition, respondents stated that patients incur less waiting time on the day of the implant. A smaller device size is likely to improve patient's acceptance as well as their quality of life as the implanted device is no longer visible and leaves a smaller scare. It also means that patients previously excluded, such as children or patients who are underweight, can now benefit from the device.[26,27]

The absolute prices of both devices show large variations both between and within countries, and also depend on the total number of devices purchased by a single hospital. It was therefore not feasible to include absolute prices in the analyses. Furthermore, Reveal LINQ is sold as package with a remote monitoring system. In contrast, the Reveal XT is sold separately from the remote monitoring system. Absolute prices of the devices are therefore not directly comparable.

In many countries, including UK and the Netherlands, the costs of ICMs are covered by Diagnosis-Related Groups (DRGs). When DRG tariffs remain unchanged despite decreasing procedure cost and higher price of the technology, this will not contribute to changes in healthcare expenditures. However, moving the procedures out of the cath lab does contribute to a more efficient use of available hospital resources.

There are a few caveats of the available data included in this study. First, this study includes a small number of hospitals from three countries and, although most respondents indicated that their results were representative for other hospitals in their countries, it is not clear how generalizable the results are to other hospitals, especially as costing studies often show large variations between hospitals. Secondly, not all finance departments were able to provide all relevant information needed in our study. In these instances, data from other hospitals were used instead. As the available prices showed little differences between hospitals, this did not seem to influence the results much. External sources were used when data were unavailable from other hospitals, most notably the Dutch costing manual,[25] for which unit prices were based on various studies in numerous hospitals. Prices for medication that were not available from the hospitals' finance departments were derived from the National Health Care Institute.[28] Depending on the data availability, overhead costs could be calculated in three ways. We used the mark-up method for the UK estimates. Dutch estimates for cath lab overhead costs were available for all three methods; these varied from €177 to €240 (observed cath lab overhead costs: €177; hospital overhead costs attributed to cath lab: €240; mark-up method: €231). We therefore assumed that the mark-up method was a valid alternative if cath lab overhead costs were not directly observed. Thirdly, Reveal LINQ was not yet used in routine daily practice at the time of study. Therefore, all answers were based on limited experience and expectations from physicians. Medical staff is thus at the beginning of the learning curve and time and related cost savings will be largest at the end of the learning curve.

Supplementary material

Supplementary material is available at *Europace* online.

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