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Quality and process improvement of the multidisciplinary Heart Team meeting using Lean Six Sigma

Paulien C Hoefsmit ,[1,2] Stijn Schretlen,[3] Ronald J M M Does,[4] Niels J Verouden,[5,6] H Reinier Zandbergen[1,2]

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PCH and SS contributed equally.

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[1]Cardiothoracic Surgery, Amsterdam UMC, Amsterdam, Netherlands
[2]Cardiothoracic Surgery, Amsterdam UMC Locatie AMC, Amsterdam, Netherlands
[3]Integrated Health Solutions, Medtronic Europe, Eindhoven, Netherlands
[4]Business Analytics, Amsterdam Business School, University of Amsterdam, Amsterdam, Netherlands
[5]Cardiology, Amsterdam UMC, Amsterdam, Netherlands
[6]Cardiology, Amsterdam UMC Locatie AMC, Amsterdam, Netherlands

Correspondence to
Paulien C Hoefsmit; p.hoefsmit@amsterdamumc.nl

ABSTRACT

Introduction The Heart Team is a multidisciplinary meeting for shared decision-making in cardiology and cardiothoracic surgery. A quality improvement project to optimise the Heart Team was initiated after the merger of the cardiac centres of Amsterdam University Medical Centre.

Methods Lean Six Sigma was applied with the purpose of improving efficiency and quality of care. Qualitative and quantitative analyses supported the multidisciplinary team during quality improvement sessions. Lean Six Sigma tools included process mapping, gemba walks, root cause analysis, line balancing, first time right, standardised work and poka-yoke.

Interventions Seven areas of improvement were introduced. Key elements were the improvement of the patient referral process, introduction of a structured agenda, task division and balanced planning of patients, better exchange of information, improved availability of diagnostics and supportive tools and information technology. Work agreements were introduced to support a positive work culture and mutual respect.

Results Lean Six Sigma designed an optimised Heart Team to improve efficiency by better resource utilisation, first time right decision-making, patient selection, complete and better access to information and elimination of waste. It leads to higher quality of decision-making by involving physicians in a more structured preparation, attendance of an imaging cardiologist, meeting duration within limits, installation of standard operating procedures, increased involvement of the referring cardiologists and a better engaged team.

Conclusions Heart Teams are essential to make evidence-based, patient-centred treatment plans for optimal patient outcomes. However, clinical practice and experience showed that it is challenging to have an efficient and effective discussion with complete patient information and to bring together healthcare professionals. The application of Lean Six Sigma resulted in an optimised Heart Team and created a best practice design for patient-centred, evidence-based decision-making. After implementation and process stability, a postintervention analysis could clarify long-term success and sustainability.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Heart Teams are multidisciplinary team meetings for complex cardiac patients in cardiology and cardiothoracic surgery. It is essential to make evidence-based, patient-centred treatment plans for optimal patient outcomes. However, clinical practice and experience showed that it is challenging to have an efficient and effective discussion with complete patient information and to bring together healthcare professionals.

WHAT THIS STUDY ADDS

⇒ The merger of two academic centres in Amsterdam, The Netherlands, is a unique situation. It consequently led to the centralisation of the cardiac centre. Lean Six Sigma was applied to integrate and create a best practice Heart Team design for patient-centred, evidence-based decision-making. To the best of our knowledge, this is the first article sharing knowledge on quality and process improvement through the application of Lean Six Sigma to optimise multidisciplinary team meetings.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Heart Teams are the backbone of cardiovascular interventions in which the essence of medical practice can be found. It is the start of a patient's journey. If decision-making is suboptimal in the Heart Team, it affects the entire care process. The importance of Heart Teams is perhaps underexposed, since there is an increased attention on limited resources and capacity on the operating room and intensive care unit that has been aggravated after the COVID-19 pandemic. The application of quality improvement methodologies, such as Lean Six Sigma, provided a structured approach to design an optimal Heart Team by creating the fundament for optimal, best evidence, shared decision-making. This establishes the best conditions so that an optimal treatment strategy can be advised that results in the highest quality of care. The project can inspire other hospitals to introduce quality and process improvement themselves.

INTRODUCTION

The Heart Team (HT) is a multidisciplinary meeting for shared decision-making in cardiology and cardiothoracic surgery. Since 2010, HTs have been integrated into the European Society of Cardiology revascularisation guidelines.[1] During the HT meeting, treatment plans for complex cardiac patients are discussed with the purpose of providing an optimal, best evidence, patient-centred treatment strategy in a shared decision-making environment.[2 3] For example, the decision for either medical therapy, percutaneous coronary intervention or coronary artery bypass graft (CABG) for patients with coronary artery disease (CAD) is made with consideration of patient characteristics and preferences, local expertise and procedural or operational risk as displayed with the SYNTAX and the European System for Cardiac Operative Risk Evaluation II.[4 5] The implementation of an HT proved to provide a designated approach to evaluating complex cardiac patients.[6] HTs are expanded to other cardiac conditions, such as heart failure, endocarditis and congenital cardiac diseases.

It is essential that the HT functions optimally to strive for the best treatment plan for each individual patient. However, a process and quality-related potential for improvement exists. To start with, not all centres have implemented an HT with required elements for an optimal performance. Therefore, the first potential for improvement would be to implement HTs in all centres. Yates *et al* reported that only 8% of patients with severe CAD were discussed at a multidisciplinary meeting after the introduction of the 2010 guidelines on myocardial revascularisation at a large-volume cardiac centre in the UK in 2014.[7] Besides the implementation of HTs in daily clinical practice, there is a significant potential for improvement of the process of the HT itself.[8–10] Consistency of HT decisions was evaluated by Pavlidis *et al* by prospectively analysing 51 HTs and 399 patients.[9] They found that in 20% of identical cases, a different treatment strategy was advised by the HT. This suggests that HT decisions are not entirely reproducible, and patients with similar conditions may have different treatment strategies and consequently outcomes. Thus, another potential for improvement of the HT could be a reduction of variation of decision-making. A more standardised HT process could result in more reproducible decisions and herewith quality of care.

Incomplete information and inadequate documentation are elements that can cause inefficiencies of the HT process. These inefficiencies could result in deviations from HT decisions, suboptimal organised waiting list and rediscussions. This again could affect the entire care pathway, since suboptimal preparation of patients can lead to last-minute cancellations.[11] Due to the COVID-19 pandemic, the time to treatment is increased since resources and capacity are progressively limited.[12–15] Prolonged time to treatment for patients with severe CAD and valve pathology can plausibly lead to more adverse events (both prior the invasive procedure and perioperatively).[12 14 16 17] Comprehensive documentation and delivery of complete patient information contributes to better insight of patients and their conditions, priority and risk of adverse events.[14 18] It is therefore necessary to organise waitlists adequately, which can be achieved at the start of the care pathway concomitant with the HT.

In the concept of value-based healthcare, optimising the HT by striving for efficiency contributes to better accessibility, affordability and quality of care.[19] Lean Six Sigma (LSS) is a quality improvement (QI) methodology originated from the manufacturing industry that has the potential to create and implement improvements throughout the organisation by its data-driven, in-depth multidisciplinary approach to improve both process efficiency and quality of care.[11 20 21] The cardiac centre (cardiology and cardiothoracic surgery department) of the Amsterdam University Medical Centre (Amsterdam UMC), the Netherlands, initiated a QI project to optimise the HT with the aim of improving efficiency and quality of care. In 2019, the merger of two academic hospitals to Amsterdam UMC led to the lateralisation of the cardiac centre (cardiothoracic surgery and cardiology department) to one location with expected completion in 2024. For over 10 years, both centres integrated the concept of an HT as a multidisciplinary approach to provide the best treatment strategy for cardiac patients. Optimal shared decision-making directly impacts quality of care, creates educational value, optimises efficiency and positions the hospital for referring centres.[22] The project is in concordance with the six aims for improvement prioritised by the STEEEP principles: safe, timely, effective, efficient, equitable and patient-centred care.[23] The purpose was to apply LSS to support the merger of the HTs and to create opportunities for a synergic integration of best practices and aimed to study the following: (1) identification of the current HT process and its performance, quality and efficiency, measured by Critical to Quality (CTQ) characteristics, (2) identification of the root causes of problems and (3) introduction of the countermeasures improving the HT's CTQ characteristics.

METHODS

This is a QI report according to the Standards for Quality Improvement Reporting Excellence Guidelines 2.0.[24] The project was performed at the cardiac centre of Amsterdam UMC, the Netherlands, and started on 1 September 2021 until 1 January 2022 in collaboration with experts from Integrated Health Solutions, Medtronic. All team members were familiar with the basics of LSS, and the project leaders were certified (Master) Black Belts.[25]

Lean Six Sigma

The project applied LSS and used the Define, Measure, Analyse, Improve and Control (DMAIC) cycle.[25–27] In the Define phase, the goal, scope, process and business case were defined. The multidisciplinary team consisted of two cardiothoracic surgeons, two cardiologists, two members of the surgical and cardiology planning team and business intelligence representatives. Both premerger locations were represented equally. Five DMAIC problem-solving sessions took place. In the Measure phase, data were collected based on the chosen performance metrics named CTQ characteristics. Process mapping and gemba walks (shop floor observations) were performed to better understand the processes. A SIPOC (suppliers, inputs, process, outputs, customers) diagram was visualised for documenting the process. Interviews with healthcare professionals and surveys measure staff and referring centre satisfaction, understand their requirements and identify bottlenecks in the process. The Analyse phase was used to determine the causes of inefficiencies in the process and to define countermeasures to improve value and flow. The Five Whys technique identified root causes of the problems. The lean tools line balancing, poka-yoke, failure demand, first time right and standardisation supported the team to identify countermeasures to eliminate waste in the current process. The project team was inspired by best practices from other hospitals and literature. During the Improve phase, the project team developed and implemented improvements. The Control phase will be used to measure final capability of the process when stability is reached and to sustain the gains and set up for continuous improvement.

Data collection and analysis

Quantitative and qualitative data collection supported the LSS project to obtain understanding of the baseline performance of the HT in line with the CTQ characteristics. Data were extracted from the hospital information system and collected in a separate database. Missing data were added through patient file inspection. All patients discussed during the HT meeting of both centres between April 2019 and April 2020 were included. Metrics included number of patients referred to the HT per year and per day, total time spent per patient on average in minutes (calculated by the sum of time spent by all HT resources as reported by planners and physicians, divided by the number of unique patients per year), time from referral to HT decision in days and percentage of patients who were rediscussed with the reason for rediscussion (during rediscussions patients were discussed more than once within the same referral). Qualitative data collection was performed through interviews with healthcare professionals (n=17) and surveys to measure staff (n=14) and referring centres (n=21). The staff and referring centre satisfaction was measured with a score from 1 to 10. There were seven HT observations performed that categorised: value-added time (discussion), required time (administration, searching for patient information) and non-value-added time (late start, waiting, disturbances and unnecessary discussion of patients). Analysis was performed using Minitab Statistical Software V.18.1.

RESULTS

Seven CTQ characteristics were identified by the multidisciplinary project team, which were valued as crucial to drive and measure quality and efficiency of the HT. The CTQ flow down presents the relation of strategic goals of the project to measurable CTQ characteristics (figure 1).[25] Process mapping and SIPOC were performed to identify the process. The Five Whys root cause analysis is presented in figure 2. The HT process was divided into six phases: referral, triage, preparation, HT, follow-up and treatment.

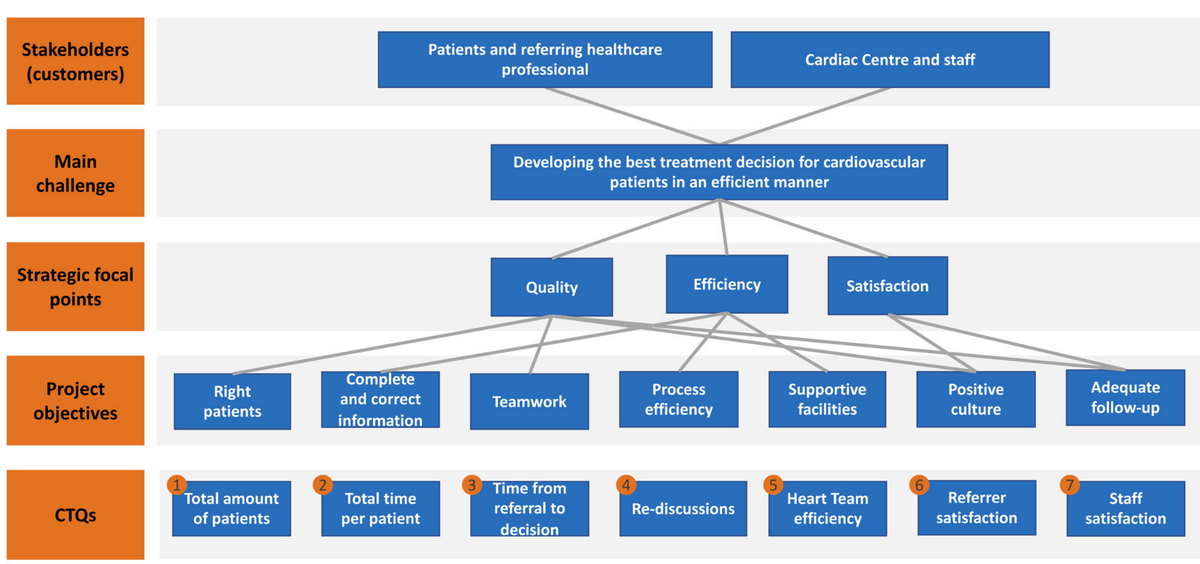

Figure 1 Critical to Quality (CTQ) flow down.

Figure 2 Five Whys Root Cause Analysis. HT, Heart Team.

1. Number of patients referred to HT per year and per day.
2. Total time spent per patient on average in minutes.
3. Lead time: time from referral to HT decision in days.
4. Rediscussions: percentage of patients discussed more than once within the same referral.
5. HT efficiency: proportion of value-added time of the HT.
6. Referrer satisfaction.
7. Staff satisfaction.

Measure

From April 2020 to April 2021, 3500 consecutive patients were discussed during 250 HTs at both locations (location A 64%, n=2250 and location B 36%, n=1250). An average of 14 patients were discussed per day (location A n=9, location B n=5), with a range of 5–25 patients per day. The sum of time spent by healthcare professionals related to HTs per year divided by the number of unique HT patients resulted in an average time of 64 min per patient per HT discussion. The median time from referral to decision was 2 days, which was considered acceptable by the project team. Patients discussed in the HT once (first time rights) occurred in 77%. Rediscussions occurred in 23% of the patients. The main reasons for rediscussions were incomplete information/diagnostics, not enough time to finish discussion list and expertise not present. Time measurements of the HT performance showed that only 46% of the time was spent on value-added activity, which was considered the actual patient discussion contribution to a decision on a treatment strategy. There were interviews with referring specialists (n=17), surveys with staff (n=14) and referring centres (n=21). Overall staff satisfaction scored an average of 5.8 out of 10 (SD 1.2). Specifically concerning the quality of the decision, staff scored an average of 7.0 out of 10 (SD 1.1), efficiency of the process 5.5 (SD 1.7), communication 5.5 (SD 1.8) and support 5.3 (SD 1.6). Overall satisfaction by referring centres was scored 6.6 out of 10 (SD 1.0). The admission process scored 7.4 (SD 0.7), communication with planning team 7.3 (SD 1.4), communication with doctors 6.5 (SD 1.6), information resources 6.5 (SD 1.2), involvement within decision of HT 6.4 (SD 1.1) and information technology tools and infrastructure 5.7 (SD 1.9). Survey respondents defined characteristics of a successful HT as follows: an evidence-based, patient-centred, optimal treatment advice through a structured discussion including necessary information, transparency and clarification on the decision and responsibilities, fast and transparent communication to referrer and service that is trustworthy and provides perspective into referred patients. The observations of the HT efficiency resulted in the following results (figure 3). Categorised as value added was discussion (46%) and non-value-added time were administration (18%), rediscussions (18%), late start (16%) searching for patient information (10%) and disturbances (4%).

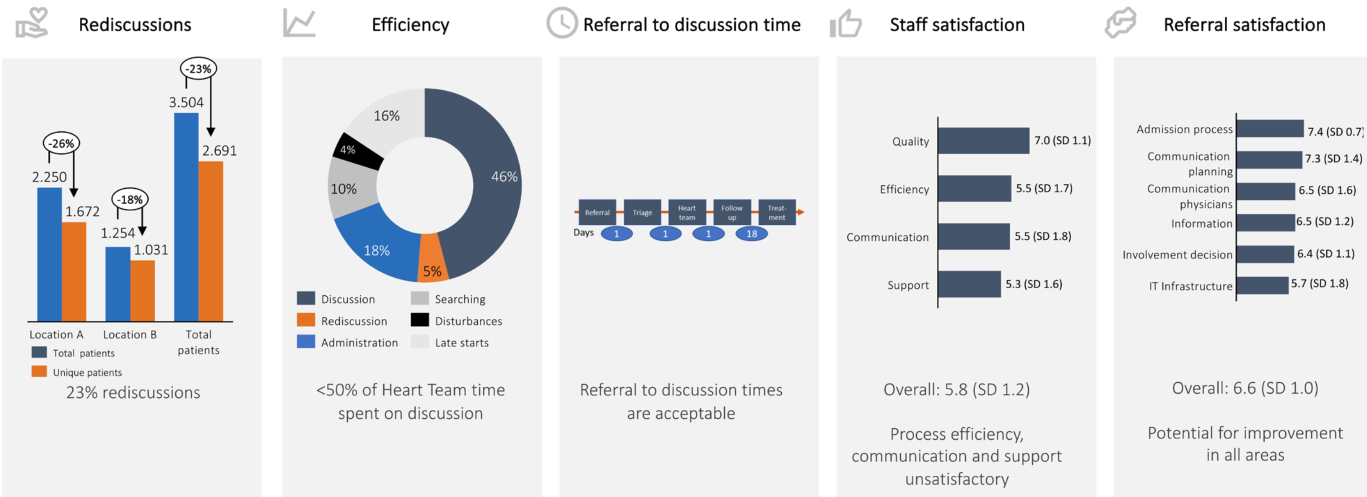

Figure 3 Results of baseline measurement. IT, information technology.

Bottlenecks and Five Whys root cause analysis

Five meetings with the multidisciplinary project team took place. Quantitative and qualitative root cause analyses resulted in a long list of 94 bottlenecks. We first categorised these into seven main improvement areas. In a matrix, these seven groups were related to the CTQ characteristics to make sure all were covered. In a failure mode and effects analysis workshop with the project group, countermeasures for most impactful and frequent bottleneck were designed based on expert opinions, literature and best practices in other centres.

With a Five Whys root cause analysis, the following root causes were defined (figure 2):

- Incomplete information or patient data for optimal decision-making during HT meetings.
- Inefficiency in work method: comprehensive amount of administration, waiting time and rework.
- Suboptimal support from facilities, information technology tools and hospital information system.
- Unclarity in structure, agenda and comprehensiveness of HT.
- Missing expectations on teamwork supported by leadership.
- Unclear tasks, roles and responsibilities.
- Lack of uniform work process and agreements.
- Unsatisfactory level of involvement and integration of referring healthcare professional.
- No data-driven continuous improvement culture.

Six Sigma Score

The Greek symbol σ (sigma) is used in statistics as a measure of variation and has become a basis for the definition of a measure for conformance quality: the sigma metric or sigma level.[25] The sigma level indicates the performance of a process, that is, which percentage of products or service conforms to the specifications (or equivalently non-conforms to the specifications). For example, a 3 sigma level process means 6.7% non-conforming and a 6 sigma level process means a defect rate of 3.4 per million opportunities. Assuming that optimal preparation of the HT with the ideal facilitation of patient information and expertise would lead to almost 100% first time right (~6 sigma), the current sigma score with 75% first time right would be 25% non-conforming or 2.2 sigma level.

The HT design

The application of LSS resulted in a new designed and optimised process of the HT. The improvements were organised in seven areas. After implementation, the improvements are expected to have beneficial consequences on the CTQ characteristics, as reported in table 1. Information was gathered from both premerger locations and other centres for benchmarking that was used to identify the HT's best practices.

Coherent and structured HT

Integrating two HTs into one

In the premerger stage, two cardiac centres scheduled two separate HTs daily during work days. Both HTs were different in process, structure, agenda and subspecialty of the attending healthcare professionals. The most influential differences between centres were the admission method and location for referring patients, differences in required documents, independent organisation by a department for preparation of a patient, course of events during the HT meeting, attendance and role of involved healthcare professionals, dedicated time of medical specialists, cultural factors, facilities and use of information technology tools and the communication of decision and follow-up to referring centres. The LSS principle of standardised work inspired the project team to focus on reduction of variation between and within the HT. A standardised process was expected to increase focus on content and reduces ad hoc activities to act on deviations. By centralisation to one location, and thus having one HT instead of two, the process efficiency (CTQ 5) and staff satisfaction (CTQ 7) are expected to be of more optimal use of resources and healthcare professionals' time. From both centres, best practices were shared during the QI

Table 1 Impact improvements on CTQ characteristics

CTQ characteristics	Baseline	New Heart Team design
1 Number of patients referred	3500 patients per year in both centres. An average of 14 patients were discussed per day (location A n=9, location B n=5), with a range of 5–25 patients per day.	Provides the opportunity to grow by better satisfaction. Maximum of 15 patients per day with low SD.
2 Total time spent per HT patient on average in minutes	64 min (without imaging cardiologist) 75 min (with imaging cardiologist)	Although imaging cardiologist will take seat in every HT, reduced rediscussions and more efficient discussions reduce the expected total time spent per patient to 53 min (reduction of 30%).
3 Lead time: time from referral to HT decision	Majority 1–2 days, rediscussions add lead time.	Prevents rediscussions, thus reduction is expected.
4 Rediscussions	23% The main reasons: information/diagnostics incomplete, not enough time to finish discussion list and expertise not present.	All prerequisites in place to make decisions first time right, expected to result in less rediscussions and less last-minute cancellations.
5 HT efficiency: value-added time	Value-added time: 46% is spent on patient discussions. Non-value-added time: external disturbances (4%), late start (16%), rediscussions (18%), administration (18%) and searching for patient information (10%).	A better prepared HT, as well as a more structured, orchestrated and timely HT, is expected to reduce non-value-added activities (waste) and increases the proportion of value-added time.
6 Referrer satisfaction	Overall: 6.6 (SD 1.0) Admission process: 7.4 (SD 0.7) Communication planning: 7.3 (SD 1.4) Communication physicians: 6.5 (SD 1.6) Information: 6.5 (SD 1.2) Involvement: 6.4 (SD 1.1) IT infrastructure: 5.7 (SD 1.9)	At least a score of 7 out of 10 is expected because of: ► Proactive expectation management. ► Better communication. ► Informing/communicating on reasons for decision. ► Involvement.
7 Staff satisfaction	Overall: 5.8 (SD 1.2) Efficiency: 5.5 (SD 1.7) Support: 5.3 (SD 1.6) Quality: 7.0 (SD 1.1) Communication: 5.5 (SD 1.8)	At least a score of 7 out of 10 is expected because of: ► Improved work circumstances, facilities and culture. ► Clearer tasks, expectations and responsibilities. ► Reduced administration burden.

CTQ, Critical to Quality; HT, Heart Team; IT, information technology; SD, Standard Deviation.

sessions, which contributed to a synergic development of new working agreements.

Redesigning the HT structure and differentiation of HT per subspecialty

There were 11 different subspecialised HTs in both centres: general (CAD and valve disease), transcatheter heart valve implantations, congenital cardiology, endocarditis, high risk, high-risk rhythm conditions, devices, electrical cardioversion and chronic total occlusion CAD on different locations. Because of the redesign, the content and structure of the HT was transformed (figure 4) to gain more focus on the selection, triage and discussion of the right patients at the right place, with the right expertise. This is expected to reduce waste (CTQ 2), improve process efficiency (CTQ 5) and first time right discussions (CTQ 4).

Triage of patients

Triage of patients by doctors together with the support of secretaries and medical planners resulted in two improvements: (1) only patients needed to be discussed were added to the HT agenda which prevents unnecessary patient discussions (within lean known as overprocessing), and (2) if patients needed to be discussed in subspecialised HTs, they were directly referred instead of via the general HT meetings. Decided by the doctors, low-complex patients for which a discussion would not have additional value were left out of the discussion list. Furthermore, an automatic system for triage based on external referrals was designed. Better preparation of the HT was required, so that time could be more efficiently spent during the HT meeting. Integrated in the hospital information system, a care pathway was developed to clarify and outline the process steps required and if necessary, space to add extra activities.

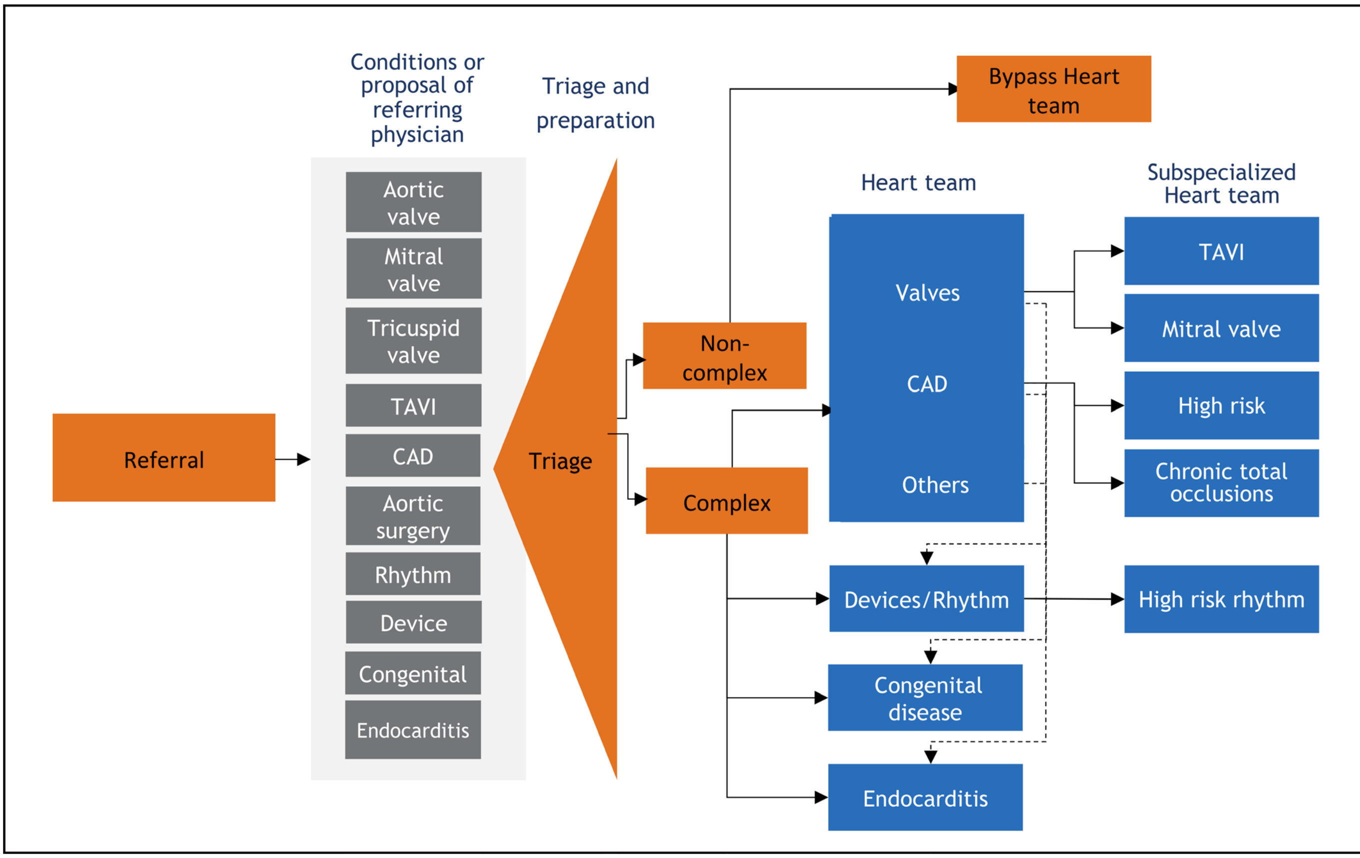

Figure 4 Triage and structure. CAD, coronary artery disease; TAVI, transcatheter aortic valve implantation.

Complete patient information

The survey with referring centres scored 7.4 out of 10 (SD 0.7) on the admission process. Rediscussions occurred in 23% of the cases on average (26% in location A and 18% in location B). Incompleteness of data was the major cause for rediscussions, which was considered as preventable. Interviews with stakeholders identified the incompleteness of information as bottleneck. The involved medical planners stated that incomplete data led to rework and non-value-adding activities and wasteful time. The root cause of this problem was identified as the lack of uniformity in admission criteria and process. Before the project, there were multiple methods, requirements and locations for admission to the HT. There was no standardised requirement for patient information. Improvements were identified that led to the organisation of a central admission point per department. One location for referrals for cardiology and cardiothoracic surgery was organised with all a standardised method and similar requirements for documentation. A standardised and clarified overview was developed to inform referring centres of the admission process, including information provided for specific medical conditions (CAD, valve disease, rhythm conditions, aortic disease, congenital heart disease and others). This improvement ensured completeness of patient information. By improving the process of admission, countermeasures were introduced that contributed to improving the first time rights (CTQ 4). Following the lean principle of poka-yoke (mistake proofing), a mandatory checklist was integrated into the hospital information system to prevent passing patient cases with incomplete information to the HT. Also, the quality of the images was assessed. If not of a substantial quality to form a treatment plan, the referring centre was asked for better images prior to HT to prevent rework. This contributed to improved process efficiency (CTQ 5) and staff satisfaction (CTQ 7).

Structured agenda and balanced planning

A total of 14 patients were discussed per day (location A n=9, location B n=5) on average, with a variability of 5–25 patients per day. This variability led to suboptimal time division, peaks in demand and stress levels, and consequently dissatisfaction of involved healthcare professionals. For example, it frequently occurred that on certain days 20 patients needed to be discussed, and the day after there were only 5. The agenda of the HT was transformed into two parts: valve disease and CAD. Per HT, prespecified time slots were addressed for patients with valvular disease (30 min) and patients with CAD (60 min). Clinical and emergency patients were discussed first. Inspired by the lean principle of line balancing and takt time data analyses showed that scheduling a maximum of 15 patients per day would reduce variation in workload and consequently overburdening of staff. According to the new standard, when more than 15 patients are referred, elective patients should be scheduled and discussed during the next day's HT meeting with a maximum delay of two working days per patient. This led to more balanced number of patients to be discussed per day instead of variability in the number of discussed patients. This contributed to a better focus and satisfaction (CTQ 7) of involved healthcare professionals, which is compromised when discussing too many patients during a single meeting.

Clear responsibilities and work method for involved healthcare professionals

The survey and interviews identified a potential for improvement concerning the attendance and task division of involved healthcare professionals to better use their expertise and reduce waste of talent. Work agreements were made to improve efficiency and communication. Physicians required to be present at an HT meeting were an interventional cardiologist, a cardiothoracic surgeon and an imaging cardiologist. All physicians were appointed a specific task to improve communication, efficiency and quality. Dedicated time of medical specialist during the HT meeting prevented disturbances. Thus, the utilisation of the HT time is optimised. An HT coordinator was appointed for the administration. Because of this, cardiologists and cardiothoracic surgeons had more time for discussion. A summary of required patient data was introduced by the HT coordinator, which created a clear overview of required information for an optimal and efficient discussion. Flow diagrams were introduced in concordance with database registrations. Information technology improvements were developed with screens presenting the hospital information system overview and images. These measures improve process efficiency, quality and satisfaction and are covering all CTQ characteristics.

Patient information available, accessible and supportive information technology infrastructure

Before the project, there were different methods to share images. The differences in accessibility of images led to waste by searching for images during the HT meeting. Improvements in the process were introduced to make uniform the availability of images directly from the hospital information system instead of from different platforms. Additional screens in the discussion room for presenting the images provided a better overview and visibility of all relevant patient information. Upfront preparation of patient characteristics and clinical information ensured availability of all required information during the actual HT. This improved efficiency by reducing time spent on searching for information and improved satisfaction of HT participants. The survey with healthcare professionals involved with the HT scored the information technology support a 5.3 out of 10 (SD 1.6). Screens and an allocated room were already available before the QI project. To improve supportive facilitation and information technology, the registration method was reorganised by a standardised HT decision dashboard, based on lean principle of visual management. Diagnostics were collected and available in one centralised information technology system. Parallel with the HT, the registration of data in the hospital system is standardised and structured data input instead of free text entry is encouraged to save administration times and ease standardised data extraction for registries.

Patient-centred care and referring centre involvement

Although both premerger locations received 70% of the HT patients from referring centres, there were differences in referrer experiences (failure demand). Both quantitative and qualitative analyses provided more information on opportunities for improvement. From the analysis, there can be concluded that a more personal-focused, transparent and better facilitated efficient process is desired. Involvement of the referring centre in the HT process is expected to improve referral satisfaction. In this way, consideration of patient's preferences will be better represented, which could impact treatment decisions. A patient-centred and more tailored HT decision could be advised that it is expected to lead to better quality of care.

Clear correspondence and communication

Survey and interviews with referring cardiologists showed an unmet need to better inform referrers about the treatment decision, especially when the HT decisions deviate from the referrer's proposed decision. Inadequate communication frequently resulted in additional work and process disturbances (failure demand). It led to rework when the referrer tried to collect missing information or argumentation and referred the patient repeatedly to the HT. Referrers could often not properly reproduce to patients the reason certain treatment proposals were advised. The new way of working incorporates proactive follow-up via a standard format, with more information adjusted to the referrer's requirements. Referrers were contacted by phone when deviated from the proposed treatment. This was expected to positively impact referral satisfaction (CTQ 6) and process efficiency (CTQ 5). Referring cardiologist involvement is expected to contribute to better consideration of patient's preferences. Less time would be spent on follow-up and unclarity of HT decisions. Patient management tools ensured an overview of patients on hold, requiring additional diagnostics or other information. A template for standardised correspondence was introduced for communication of HT decision to referring centres. The HT coordinator was made responsible for this. The referrer is responsible for communicating HT decisions to patients.

Beneficial consequences

Adequate waiting list organisation

Due to the COVID-19 pandemic, the cardiac centre was challenged by limited capacity and resources. For cardiothoracic surgery, this resulted in prolonged waiting lists and referral to treatment times. It consisted of approximately 250 patients awaiting cardiac surgery at the start of the project, which was a greater amount compared

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with before the COVID-19 pandemic. Longer waiting lists and referral to treatment times made it increasingly necessary to have complete, structured waiting list organisation to provide insight of the patient's condition and risk of adverse events while awaiting cardiac surgery. In the premerger HTs, it occurred that HT decisions were made without complete information, for example, if a patient had CAD but the transthoracic ultrasound to evaluate valve disease was not yet performed, the HT had already advised on a treatment strategy and the patient was added to the waiting list. This in some cases led to new insights that changed treatment strategies during preoperative screening and eventually caused last-minute cancellations.

By the new HT design, and especially improving the quality of HT decisions by completeness of patient information, there was a better insight of a patient's status, condition and priority. This aimed to improve waiting list organisation, and consequently operating room planning and preoperative assessment.

Data-driven continuous improvement

A structural data-driven performance dashboard is developed for continuous improvement purposes. The combination of improvements aimed to improve the completeness of data for research purposes. Data collection was standardised, which simplified selection of patients for studies, clinical audit and feedback systems.

Monetary consequences

The entire HT process from preparation, patient discussion and follow-up requires time from physicians. Data analysis of the baseline situation at two locations showed that 2250 medical specialist hours per year were needed to process all referred patients. According to the study of the Dutch Healthcare Authority, one medical specialist's full-time equivalent has 1691 productive hours/year and costs the organisation about €212 000.[28] This results in €282 000 for capacity needed in total. If an imaging cardiologist would structurally take seat in all HT meetings, this number will increase to 2875 hours/year or €360 000. If both quality and efficiency measures are implemented, only 1750 hours of physicians will be needed which is equal to €219 000 of physician costs. This will result in an annual savings of €141 000. Indirect monetary consequences are the costs of poor quality. With the right information and expertise during the HT meeting, a reduction of disturbances and rush most probably leads to better treatment decisions and prioritisation of patients. This prevents cancellations due to suboptimal preparation or last-minute change of treatments.[11] In a hospital with 1000 CABG procedures annually and 15% last-minute cancellations, the amount equals about 150 CABGs per year.[11] Out of those, an estimated 20% (30 cases per year) could be prevented by a better HT and follow-up. An estimation of the average revenue per procedure of €12 000 would result in missed revenues of €360 000 annually. Another indirect monetary consequence to be expected is related to staff satisfaction. Well-trained quality staff is scarce. Creating a healthy, satisfiable working environment is a prerequisite to remaining staff. To recruit and train new staff is costly, just as to fill gaps of illness due to overburdening of staff. This is a common challenge in healthcare systems. In the long term, improvements in referring centre satisfaction may also lead to more referrals and higher revenues.

Practical implications

Several challenges were faced when implementing the change. By the merger of the two centres with two medical specialties, we were faced with four different work cultures, which challenged the design and implementation greatly. Positively seen, the merger provided an ideal situation to initiate change management and share best practices. We experienced that a data-driven scientific approach, education, engagement of all involved healthcare professionals through the LSS approach, leadership and support from the cardiac centre board supported implementing change. The most important recommendations for improving an HT are:

- Find a common goal that engages everyone, which is the quality of care for patients in this project.
- Connect the proposed countermeasures to the main goal to create buy-in from all stakeholders.
- Use data to support 'sense of urgency' and to convince stakeholders for the process change.
- Divide implementation activities into separate themes or categories and set up a governance structure with clear roles and responsibilities.
- Set up a clear communication plan to inform and engage stakeholders via multiple channels.
- Assign department leads as 'champions' to accelerate change, move barriers and facilitate implementation.
- Standardise work method to improve teamwork and create focus on content during the discussion, so that every participant knows their role/task and can follow the discussion.
- Standardise reporting of arguments and HT decisions for clear communication within hospital and for referral communication.
- Implement checklist to prevent missing information before and during the HT meeting.
- Triage patients so that they are discussed at the right place, the right time with the right expertise.
- Triage and prepare patients adequately so that there is a filter that prevents unnecessary discussions.
- Implement a structured HT agenda with consideration of the priority and condition.
- Reduce variation in workload by scheduling a maximum number of patients per day.
- Dedicate time for healthcare professionals during the HT meeting to prevent disturbances.
- Standardise accessibility of information and images in one hospital information system.
- Register and report in a manner that simplifies data extraction for registries and research.

DISCUSSION

Summary, key findings and particular strengths of the project

This QI project applied LSS to optimise the process of the HT after the merger of two academic medical centres in the Netherlands. The application of a QI methodology led to the identification and implementation of countermeasures based on the root cause of problems, supported by data based on seven CTQ characteristics. As a result, an improved HT is designed. Efficiency is improved by decreased rediscussions through first time rights. Triage of low-complexity patients by the cardiologist or cardiothoracic surgeon prevented unnecessary discussions. Less time is spent per patient through preparation, the availability of complete patient information, improved accessibility of diagnostics and the support of an HT coordinator. Work agreements resulted in less disturbances. Quality of care is improved because of the admission of an imaging cardiologist to the team, more involvement of referring cardiologist in decision-making and communication, and the creation of an optimal organisation for evidence-based, patient-centred and shared decision-making. Furthermore, an improved administration of the HT resulted in better organisation of the waiting lists, and thus provided better insights of the patient's conditions, priority and risk of adverse events. This is especially necessary in times when the risk of adverse events is increased by longer referral to treatment times, caused by lower productivity due to the resource scarcity that developed during the COVID-19 pandemic.[12–15] The project is in concordance with the STEEEP principles focused on quality through the involvement of the patient and referral's preferences, process efficiency, better insight and organisation of the waiting list, timeliness and effectiveness.

The merger of two academic centres in the Netherlands created a unique opportunity to integrate both best practices. Strengths of this project are the data-driven multidisciplinary approach. The project team identified CTQ characteristics, and translated efficiency and quality into measurable elements. Nevertheless, it would be informative, for instance, what the effect of the optimised HT is on other process metrics such as last-minute cancellations. The application of LSS ensured a methodological approach to identify the correct improvements based on the bottlenecks experienced and the root cause of problems. Also, the strength of the application of a QI methodology finds itself in the implementation of the improvements in the process. Because of this, together with a multidisciplinary approach and the involvement of healthcare professionals throughout the organisation, the optimised HT is better supported.

The importance of shared decision-making for CAD by an HT has been reported as essential for the quality of care.[1 16] Therefore, the first importance is to use and implement an HT. The SYNTAX trial and other publications showed the benefits of a multidisciplinary approach in cardiovascular medicine.[6 10 29 30] A shift to surgical revascularisation was seen since the implementation of the multidisciplinary team and the time interval from referral to revascularisation was shortened.[10] Consequently, guidelines for myocardial revascularisation and percutaneous coronary intervention included the multidisciplinary approach as a class 1C recommendation.[1] Moreover, if the HT is implemented in an organisation, it should function optimally and needs to contain the preconditions required for optimal evidence-based multidisciplinary decision-making. This can be divided into process elements and cultural factors. Certain preconditions for an optimal performance of an HT are advised, including the presence of an imaging cardiologist, an interventional cardiologist and a cardiac surgeon, shared decision-making with consideration of the patient's preferences, a dedicated room with supporting tools, leadership, complete and available patient information, support of HT coordinator and a safe culture with positive dynamic with mutual respect where all contributions are acknowledged.[31] Other process elements contributing to improved efficiency are the structured agenda, work agreements, leadership and task division. A set number of patients to discuss guarded focus and ensured enough time to discuss all the patients. Furthermore, cultural factors were improved through work agreements. For example, the HT decision is leading which consequently demonstrated the importance of shared decision-making and prevented unnecessary deviations from HT decision. Better communication to referring centres improved satisfaction. Raine *et al* performed a prospective observational study to the effectiveness of multidisciplinary meetings. They identified recommendations for improving the effectiveness of multidisciplinary team meetings, mainly focused on the following elements: purpose, processes, content of discussion (availability of patient information) and the role of the patient. The observations of the HTs showed that abundant time is spent suboptimally, and only 46% of time for content-related discussion. Therefore, the project led to the implementation of countermeasures to use the HT time more efficiently.[32] Improved organisation creates a better support for optimal shared decision-making, and therefore contributes to quality of care. Lamb *et al* performed a systematic review on the quality of clinical decision-making through multidisciplinary cancer teams and included 37 studies.[33] They have reported that there is potential for improvement related to taking the patient's preferences into account. Furthermore, issues pointed out in their conclusion are that time pressure, excessive case load, low attendance, poor teamwork and lack of leadership lead to incomplete information and deterioration of decision-making. In the current project, the issues are similar for which the application of LSS provided countermeasures based on the root cause of problems. LSS has proven to be effective in healthcare through minimising costs, reducing waiting lists and referral to treatment times and maximising patient safety.[20 21 34] Alongside with standardising and optimalisation of processes, LSS has considerable impact on a cultural change in teamwork and a sense of common goal. To the best of our knowledge, studies related to the application of LSS to improve multidisciplinary meetings are limited. This project showed that LSS is a successful methodology and has the potential to improve the quality, efficiency and culture of multidisciplinary meetings. It provided a structured and effective approach to eliminate inefficiency and to improve the process, so that preconditions for an optimal HT are met and a fundament is created to ensure optimal shared decision-making. It focused on five principles: define value, map the value stream, create flow, establish pull and pursue perfection.

After the design phase, the new HT design was presented to the cardiac centre board. They approved the full implementation. All healthcare professionals were educated and informed about the new HT design and work method. Prerequisites took place that made it possible to change. For a couple of weeks, the cardiac centre board and members from the project team were present during the HT meeting to assist during the change. After full implementation and stability of the HT new design, a postintervention study on the outcomes would be informative to clarify long-term success.

In the future, HT decision-making can be supported by predictive analytics and the use of patient characteristics, process measures and retrospective data in line with the Control phase of the LSS DMAIC cycle. Complete registration of patient information in a data set is the first step for this development. An HT data set can demonstrate effectiveness of decided treatment plans, follow-up on patients discussed, evaluate patient outcomes after HT decision and monitor and improve HT efficiency. Clarke *et al* showed that the implementation of a dashboard with information tools and a clinical decision support with computer algorithms have the potential to improve HT efficiency.[35 36]

Limitations

The QI project to integrate and optimise the HT was initiated after a merger of two academic centres, which is a unique situation itself. The new design could be generalisable by sharing the application of a quality and process optimisation methodology for a HT and by sharing best practices. We argue that hospitals apply a QI methodology themselves to improve their HT, since every HT has its own specific areas for improvement. Difficulties faced with the implementation of this study were the engagement of all healthcare professionals, which was especially challenging in a merging environment. Structured interviews and involvement during QI sessions contributed to identifying best practices from each centre. Leadership and support of the cardiac centre board contributed to better support of the changes. A preintervention and postintervention study could inform if the improvements led to statistically significant improvements, analysed by CTQs. The project led to the introduction of an HT database of patient characteristics, decisions and patient outcomes after procedures.

CONCLUSION

Multidisciplinary HT meetings are essential to make evidence-based, patient-centred treatment plans for optimal patient outcomes. However, clinical practice and experience showed that it is challenging to have an efficient and effective discussion with complete and available patient information and to bring together healthcare professionals. Through the application of LSS, the project team designed an optimised HT in a merged academic cardiac centre and created a best practice design for patient-centred, evidence-based decision-making. Data-driven structured problem-solving techniques were key to identify root causes for problems. Countermeasures were implemented to improve quality, efficiency and satisfaction. The project can inspire other hospitals to introduce quality and process improvement themselves. After achieving process stability, a postintervention measurement could clarify long-term project success. Effectivity of HT decisions on patient outcomes and process measures will be further investigated, starting with a structured HT data set and the introduction of continuous improvement cycles.

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ORCID iD

Paulien C Hoefsmit http://orcid.org/0000-0003-4019-7197

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