VALUE BASED DECISION SUPPORT TO PRIORITIZE INNOVATIVE TECHNOLOGIES FOR VASCULAR SURGERY IN THE HYBRID OPERATING THEATER

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Value Based Decision Support to prioritize Innovative Technologies for Vascular Surgery in the Hybrid Operating Theater

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Introduction. The current hybrid operating theater (HOT) offers improved efficiency and health outcomes for (endo)vascular procedures, such as endovascular aneurysm repair (EVAR). Innovative technologies for minimally invasive interventions have the potential to further increase the value of the HOT. Restricted development budgets require prioritization of the development of these technologies. A structured methodology to deal with the (possibly conflicting) criteria of vascular surgeons in prioritizing the added value of new technologies has not yet been reported. **Methods.** We propose a multi-criteria decision analysis framework to evaluate the value of innovative technologies for the HOT based on the MACBETH methodology. The main surgical procedures are incorporated in the framework and interdependencies between the technologies are evaluated. The framework is applied to a specific case: the new HOT in the Medisch Spectrum Twente (MST) hospital, Netherlands. Three upcoming innovations (wound perfusion measurement, improved angiographic imaging technologies and guided steering assistance) are scored for three distinguished endovascular procedures (crural revascularization for peripheral aortic occlusive disease (PAOD), (Fenestrated) EVAR and Thoracic EVAR) based on six performance criteria. The criteria are based on a literature search towards outcome measures. Weights and performance scores for each criteria are based on interviews with two vascular surgeons from MST. The scores are multiplied with the fraction that procedure is performed to calculate overall value. **Results.** A wound perfusion measurement would add most value to the procedures for PAOD patients, while the other upcoming innovations would be about equally beneficial to the (F)EVAR and TEVAR procedures. Overall, the wound perfusion measurement technique would add most value to the current HOT. **Conclusion.** The novel framework proved useful to prioritize the development of innovative technologies for the HOT. When development costs would be similar, priority should be given to the development of a wound perfusion measurement technique.

1. INTRODUCTION

The emergence of endovascular procedures such as endovascular aneurysm repair (EVAR) and crural revascularization of peripheral aortic occlusive disease (PAOD) has changed the field of vascular surgery for good, even though the discussion about the cost-effectiveness of these procedures is still ongoing (Van Bochove et al., 2016; White & Gray, 2007). Optimal imaging and technical functionality for endovascular procedures are achieved with a dedicated integrated theater (Kaneko & Davidson, 2014), which for many hospitals has led to the adoption of the so-called hybrid operating theater (HOT). The diffusion of the HOT has been catalyzed by several advantages of the HOT compared to the use of standard mobile C-arms. The advantages following have been described: a) increased field of view, translating into fewer injections and radiation exposure (Pomposelli, 2010); b) improved sensitivity and image quality; c) reduced ionizing radiation for patient and personnel; d) smart handling that simplifies positioning and accelerates the procedure; e) software for overlays of images taken at different time points improves detection of endoleaks (Steinbauer, Töpel, & Verhoeven, 2012).

These technological advantages offer the potential of improved health outcome for patients by smaller chance of complications, shorter treatments and less exposure to ionizing radiation and iodine contrast. On the other hand, a HOT is more expensive than a standard OT with mobile C-arm, mainly due to the increased size of the HOT and the expensive imaging equipment (Kpodonu, 2010; Siddharth V, 2014). The discussion about the cost effectiveness of the HOT is therefore important (Field, Sammut, Kuduvalli, Oo, & Rashid, 2009). Since cost effectiveness will depend on improved health outcomes and improved efficiency, the outcome of such an analysis is likely to differ between procedure types. Initial research towards the value of the HOT on EVAR reported greater efficiency, improved health outcomes and a reduction in received ionizing radiation (Hertault et al., 2014; Varu, Greenberg, & Lee, 2013). To improve the value of the HOT further, and thus improve cost effectiveness, new innovation in the HOT might prove useful.

Concurrent with research on the benefits of current HOTs, new innovative technologies for vascular surgery are being developed. Examples of such technologies include tools for wound perfusion measurement, improved angiographic imaging technologies and guided steering assistance (De Ruiter, Moll, & Van Herwaarden, 2015; Nollert, Schwabenland, Sunderbrink, & Dyck, 2015). In the long term, these and other novel technologies could be implemented in the HOT to overcome current limitations, such as the ionizing radiation that the patient receives in the EVAR procedures (Maurel et al., 2012) and limited information about the perfusion of the diabetic foot ulcer of PAOD patients (Brownrigg et al., 2016). This brings up interesting questions: Which innovative technologies are most likely to lead to substantially improved patient health outcomes, healthcare efficiency and patient recovery times? And, can we prioritize the development and implementation of new technologies?

In this paper we propose a framework to answer these questions and thereby support decision making at different levels. If insight is gained into which innovative technology is most valuable for which patient group, time and budget spending can be prioritized to focus research and development efforts. In subsequent stadia, when innovative technologies are brought to the market, hospitals can use the framework to determine which portfolio of technology offers them most value within their spending budget. In this paper we illustrate the use of the framework in a specific case: the new HOT in Medisch Spectrum Twente (MST), which is used by vascular surgeons for EVAR, fenestrated EVAR (FEVAR), thoracic EVAR (TEVAR), and PAOD procedures and by cardiac surgeons for TAVI procedures.

At present, we compare the potential added value of three completely different upcoming innovative technologies: wound perfusion measurement, improved angiographic imaging technology and guided steering assistance in a HOT environment.

2. FRAMEWORK

2.1 MCDA

One of the standard methods to conduct early technology assessments, is the use of multi-criteria decision analysis (MCDA) methodology (Diaby, Campbell, & Goeree, 2013). In an MCDA, the value of each alternative is determined by scoring multiple (possibly conflicting) performance criteria. The criteria should be defined such that they include all important outcome measures with minimal overlap between criteria. For example, if one criterion states *the amount and effect of iodine contrast agent*, and a second criterion *clinical success* is introduced, the latter should exclude the health effects induced by iodine contrast, otherwise the effect would be included twice.

Several MCDA techniques have been developed and overviews focused specifically on healthcare are available (Broekhuizen, Groothuis-Oudshoorn, van Til, Hummel, & IJzerman, 2015; Dolan, 2010). Different MCDA methods exist, each with their own (dis)advantages (Diaby et al., 2013). For our illustration, we measured attractiveness by a categorical based evaluation technique (MACBETH) (Bana e Costa & Vansnick, 1999; Rodrigues, 2014) which offers the possibility to directly include performance data about effectivity and other parameters. MACBETH requires a value function for each criterion which describes the relation between score and performance. The starting point of this function (at which the score is 0) is defined by the clinical standard practice prior to introduction of the HOT, while the endpoint is independently defined for each criterion as the optimal future performance. In line with MACBETH methodology, the importance of an improvement in performance from 0 to 100 of each criterion is pairwise compared along a seven point scale. Finally, the performance of the innovative technologies can be valued for each criterion based on measured data, evidence from literature, or expert elicitation. Given that we consider an early health technology assessment about innovative technology, the amount of available data is very limited and expert opinions are used as input. The resulting overall value of each innovative technology is calculated by summing the multiplication of scores with weights for all performance criteria.

2.2 Portfolio analysis of different scenarios

To value a possible variety of future uses of the HOT, another layer of modeling is added to the MCDA framework. Within the HOT several procedures are performed and it can be expected that the HOT adds more value for some of these clinical procedures. For future innovative technologies, expectations are no different. Some innovations will add more value to specific procedures. Therefore, it is vital to include different future scenarios in which only one or a subset of procedures is performed. Otherwise, information about which procedure is most interesting to perform in the HOT will be lost. In contrast to traditional scenario analysis, we do not focus on the plausibility of each scenario (Enzmann, Beauchamp Jr, & Norbash, 2011; Schoemaker, 1995), assuming that at this research phase we can use the current distribution of procedures.

In a scenario analysis, the MCDA is completed for each scenario (procedure). Theoretically, every part of the MCDA can be different, including the list of criteria, the weight factors and the scoring. For our case however, the MCDA is performed for vascular procedures only, so the criteria itself can be kept the same. However, the starting point and end point that define the value function of each criteria will differ for the procedures and thus the weight factors are likely to differ for the procedures as well. As is commonly advised, we limit the amount of procedures that is included in the scenario analysis, as data collection is time consuming, and time of the involved experts limited.

Finally, a third layer of analysis is added to the framework. It can be expected that the performances of innovative technologies for some criteria are affected when they are combined with other alternatives (Lee & Kwak, 2011). An example of these interdependencies in performance of the innovations is the cost of development and implementation. Let us assume that at some point a new type of Magnetic Resonance Imaging (MRI) system offers great options for imaging during surgery, and lacks the need for a contrast agent that damages the kidneys. At the same time, a system is developed that enables perfect assessment of wound perfusion of the diabetic foot. Assume both techniques perform well on the criteria of the MCDA and are therefore expected to offer added value for the vascular outcome. However, if the metal structure that is used for the wound perfusion measurement cannot be placed in close proximity of the MRI, the value of the combination of these two techniques will be lower than the value of the sum of the individual technologies. Extra development costs will be induced when both innovations are to be employable simultaneously. Note that, this type of interdependencies is not limited to cost and is not necessarily negative. One innovation might also have the potential to enable or amplify the added value of another technology.

Together, the three levels of analysis are combined in a general framework, which is suitable to analyze the value of a variety of innovations to be used for a different clinical procedures in the HOT. An overview of the framework is shown in Figure 1.

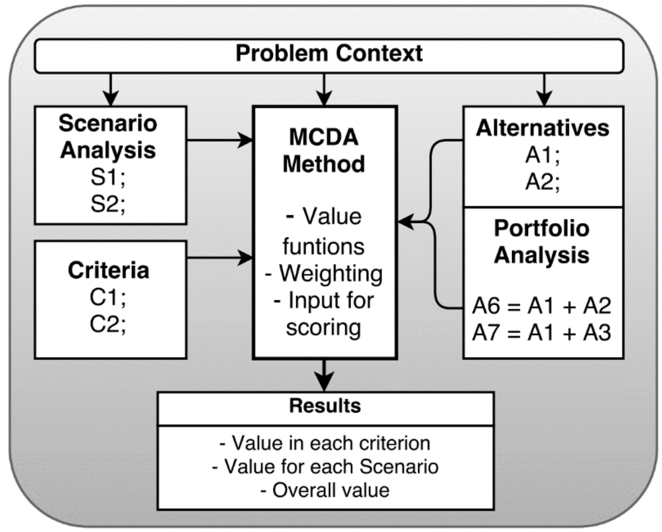

Figure 1: Framework for early health technology assessment that includes scenario analysis and portfolio analysis.

3. CASE STUDY

3.1 Problem context

In MST hospital (Enschede, the Netherlands), a new HOT was built (General Electrics discovery IGS* 740 mobile angiography system). The HOT is mainly employed for vascular surgery, and generally only a subset of vascular procedures is performed. Over a period of 24 weeks (from January 2016) 52 EVAR and FEVAR procedures (27%) and 5 TEVAR procedures (3%) were performed. Moreover, 121 PAOD (63%) patients were treated, while 14 other type procedures (7%) were performed. Two out of four vascular surgeons working at MST were interviewed to gather expert input for the MCDA. Moreover, the surgeons also provided information about the requirements for future technologies. In consultation with three technical experts from the University of Twente, familiar with the suggested type of novel technologies, a set of three innovative technologies was selected (see section 3.3).

3.2 Scenarios

The scenarios that were considered for the MCDA are shown in Table 1.

Scenario 1
Only patients that obtain crural revascularization for Peripheral Artery Occlusion Disease
Scenario 2
Only patients that undergo (Fenestrated) Endovascular Aneurysm Repair
Scenario 3
Only patients that undergo (Branched) Thoracic Endovascular Aneurysm Repair

Table 1: Scenarios considered for the MCDA

The number of scenarios was limited to three to keep data acquisition feasible. Therefore EVAR and FEVAR were considered together and the branched TEVAR were considered together with the standard TEVAR.

3.3 Alternatives & Portfolio analysis

Alternatives were established after consulting with two vascular surgeons and three technical experts. Given the early developmental stage of the technologies considered in our illustration we chose to describe each technology by their theoretical functionality instead of their detailed technical description. The advantage of the functional description is twofold. First, the vascular surgeons are not limited by their knowledge about the actual potential of an innovation that is yet to be developed. Second, engineers can use this framework and determine to what extend their expectations match the functional description as used in this example and thus get an idea of the value of their technology.

The three innovative technologies make up alternatives 1-3. We considered them only in combination with the current HOT. In order to get an idea of the value of the new innovations compared to the value of the current HOT itself, the status quo was added as alternative 0. Interdependencies in performance of the innovations can be identified by combining alternatives 1-3 into four more alternatives (4-7). An overview and description of the alternatives is given in Table 2.

Alternative 0
Current HOT Medisch Spectrum Twente
Alternative 1
Alternative 0 + Wound perfusion measurement system (Wound perfusion measurement that allows a perfect indication whether blood flow is sufficient)
Alternative 2
Alternative 0 + Continuous angiography with harmless contrast agent (an imaging technique that enables continue angiography with perfect contrast, without toxic agent and that allows surgery to be performed.
Alternative 3
Alternative 0 + Steering assistance of catheter ('Robotic' assistance for guidance of the catheter, that enables perfect steering inside the arteries)
Alternative 4
Alternative 1+2
Alternative 5
Alternative 1+3
Alternative 6
Alternative 2+3
Alternative 7
Alternative 1+2+3

Table 2: Alternatives considered in the MCDA

3.4 MCDA

An initial list of outcome measures was composed based on a literature search (data not shown). Health outcomes as well as efficiency outcomes are included since both are affected by the HOT (Varu et al., 2013). After consulting with the vascular surgeons about the importance of each measure, a set of criteria was determined. The criteria were defined such that they include the important outcome measures. Overlap across the criteria was minimized, while health effects and efficiency related outcomes were generally discriminated. The set of criteria and the description is shown in Table 3. For the sake of feasibility of the MCDA, the amount of criteria was limited to six.

Ionizing Radiation
The effect of ionizing radiation that is received by personnel and patient due to fluoroscopy time
Iodine Contrast
Risks and consequences for the patient due to iodine required to perform the procedure
Clinical Success
Success of procedure and health implications for the patient due to intraoperative complications, postoperative complications and the medical effect of reoperations during the first year. Not including health effects due to radiation or contrast agent
Efficiency of Procedure
Required time of personnel, operation time and materials related to the whole procedure, also due to changed intraoperative complications
Financial Effect of Recovery
Direct and indirect cost of recovery period of the patient, depending on the length and type of aftercare. Also including the cost of postoperative complications and reoperations during the first year.
Ergonomics of Procedure
Ergonomic experience for surgeons and other personnel during the procedure, including ergonomic improvements due to reduced time of the procedure.

Table 3: Set of criteria for MCDA

MACBETH methodology requires value functions to describe the range in which the performance is scored. Our preference for linear functions for this case is based on two considerations. First, we assumed vascular surgeons to make their value judgments with a linear value system in mind: improving the health of two patients is twice as important as improving the health of one patient. Second, interdependencies in performance will be harder to detect when non-linear value functions are used.

Criterion	Score = 100
Ionizing Radiation	No radiation
Iodine	No consequences of iodine or other

Contrast	toxic agent
Clinical Success	Ideal situation: as maximum successful procedures as possible (with respect to very long term expectations >25 y)
Efficiency of Procedure	Ideal situation: as minimum utilization as possible (with respect to very long term expectations >25 y) of personnel, operation time and material
Financial Effect of Recovery	Ideal situation: as minimum cost as reasonably possible (with respect to very long term expectations > 25y)
Ergonomics of Procedure	No long term health effects and no discomfort from performing the procedure

Table 4: Value functions related to the criteria

Starting point of each value is a standard OT used in combination with a mobile c-arm. The definition of the end point of each value function is shown in Table 4. The starting point was set to a score of '0', while the end point was set to a score of '100'. All parts of the MCDA (including the criteria, value functions, scenarios, alternatives) were established during a meeting (duration about an hour) with the two vascular surgeons after which all methods of weighting and scoring using MACBETH software (Bana e Costa & Vansnick, 1999) were clarified.

To determine the weights of the criteria a Delphi-based method (Gnatzy, Warth, von der Gracht, & Darkow, 2011) was utilized. The importance of criteria were pairwise compared by one vascular surgeon for each scenario. The resulting weight factors (summing up to one hundred for each procedure) were proposed to the second vascular surgeon who suggested a list of adjustments. The adjustments together with the arguments, were proposed to the first surgeon and lead to the final, agreed upon, weight factors.

With the value functions in mind, the vascular surgeons independently scored (0-100) alternatives 0-3 for each criteria for all three scenarios. The net scores (subtracting the score of status quo, which is alternative 0) were summed to calculate theoretical scores for alternatives 4-7. These theoretical scores where then shown to the vascular surgeons to allow them to make adjustments based on expected interdependencies in the performance of the alternatives. All scores were multiplied with the weight factors to determine the value of each innovative technology for each scenario. Then the value of each innovative technology was multiplied with the current proportion of each procedure to calculate overall value of each alternative. This analysis was performed for the individual scores of the surgeons as well as the average scores.

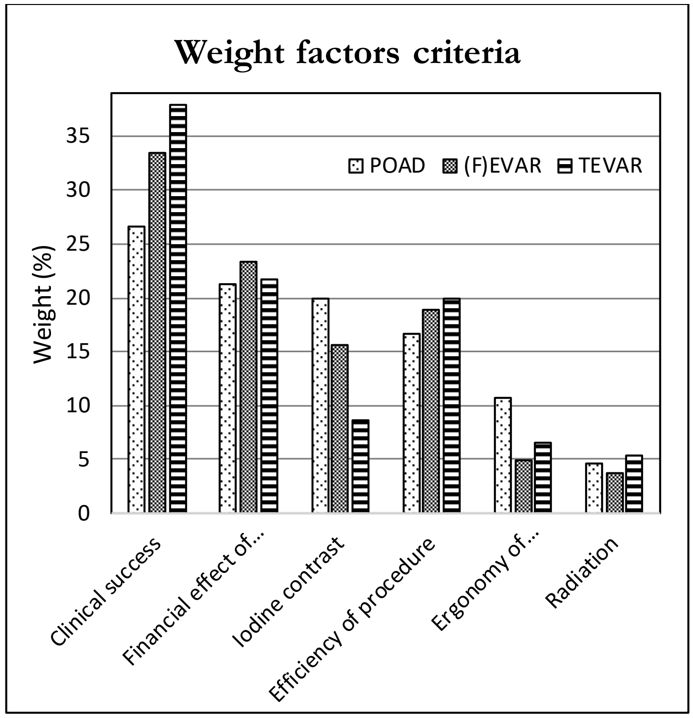

Figure 2: Weight factors of criteria for PAOD, (F)EVAR and TEVAR procedures

4. RESULTS

In this section we describe the results from the case study. Interviews with the vascular surgeons provided valuable arguments to set the weight factors of the criteria. An overview of the weights for each procedure type is shown in Figure 2. In general, a clear trend can be identified for the priority of the weights for each procedure type. The criteria clinical success and financial effect of the recovery are considered very important, while ergonomics and radiation are generally considered less important. For the TEVAR procedure, clinical success is considered to be of extra importance in comparison with the other procedures, also due to the potential to help certain patients for who previously endovascular treatment possibilities were limited. Interestingly, the criterion iodine contrast is most important for the PAOD patients even though these procedures require the least contrast agent of all three procedures. The vascular surgeons attributed the weight of this criterion to the presence of renal insufficiency, very common in patients with end-stage PAOD (Pomposelli, 2010).

Contrary to the weight factors, for which a clear consensus was reached, the scores given for each innovative technology varied between the two experts. The individual values (sum of the scores times the weights of the criteria) for alternatives 0-3 are shown in Figure 3. An overview of the values of all alternatives can be found in Appendix 1, that also provides the individual performance for each criteria.

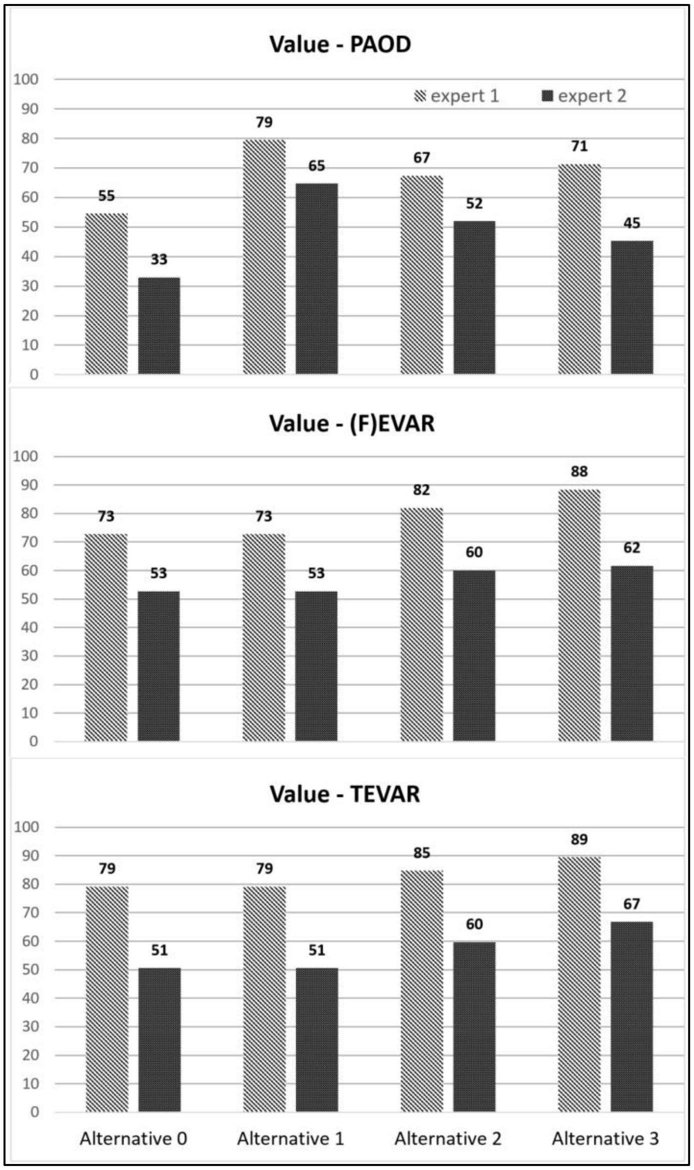

Figure 3: Value of alternatives for PAOD, (F)EVAR and TEVAR

Only one interdependency in the performance of the innovative technologies was identified. Expert 1 expected that improved angiography technology and guided steering assistance would positively affect each other with respect to efficiency of the procedure. However, due to the limited amount of interdependencies, the alternatives 4-7 were not included in Figure 3.

Although expert 1 valued each alternative always higher than the other, both vascular surgeons agree about general trends: In Figure 3, one can find that Alternative 1 only adds value to the PAOD procedure, while the other two alternatives add value for all procedures. The experts also both concluded that for the PAOD, the introduction of a wound perfusion measurement technology would add most value to the current HOT. To consider overall value, the current proportion of each procedure is included. Proportions are normalized as other type procedures have been left out for this analysis. An overview of the overall value of each alternative, for which the scores of the experts are averaged, is shown in Table 5.

From this table we can see that all alternatives have the potential to add value to the current HOT, given the current distribution of procedures. It shows that the experts value the current HOT about halfway the total value scale and that all other alternatives add between 27 and 38% to this value. Between alternatives 1-3, that represent the single innovative technologies, the wound perfusion measurement technology is expected to add most value.

Procedure	POAD	(F)EVAR	TEVAR	Overall
Proportion	63,0%	27,1%	2,6%	
Proportion normalized	68%	29%	3%	100%
Alternatives				
0	44	63	65	**49,9**
1	72	63	65	**69,1**
2	60	71	72	**63,3**
3	58	75	78	**63,8**
4	85	71	72	80,3
5	85	75	78	82,2
6	74	83	85	76,7
7	94	83	85	90,4

Table 5: Overall (averaged) values of all alternatives

5. DISCUSSION

Given the commonly high cost of development of innovative healthcare technologies for the hospital, efforts and distribution of restricted budgets need to be prioritized. Current evaluation of healthcare technology often takes place after significant investment have already been made (Şardaş et al., 2014) and literature about decision support and cost-effectiveness of technologies mainly focus on already available healthcare technologies (Wild & Langer, 2008). Specific early (economic) healthcare technology assessment reports are scarce (Levin, 2015; Pham et al., 2014) and a structured tool to prioritize development of innovative healthcare technologies for multiple scenarios is required (Steuten, 2016).

5.1 Framework

The framework proposed in this paper can be used for value based decisions for a variety of innovations. The example shown in this paper provides decision-making assistance for innovative technologies for vascular surgery at three different levels. Primarily, engineers can evaluate whether development efforts are still likely to ultimately provide the expected value. The value of each innovative technology has to be weight against cost (and uncertainties) of the development process. Large organizations, leading multiple research and development projects, can use the framework to select a portfolio of technologies that offer most value. In later stadia, when clinical data becomes available, clinicians can use the scenarios to determine which combination of technologies and procedures is most valuable. With this knowledge, allocation of the HOT (with integrated innovative technologies) can be optimized.

Regarding the HOT of MST we found that all three innovative technologies added substantial value on the 0 to 100 scale, while the HOT itself was found to be the biggest improvement compared with the conventional OT with mobile C arm situation. Of the three innovations, the wound perfusion measurement system added most value overall, and when development costs of these innovations would be similar, priority should be given to this innovation. Improved angiography technology and guided steering assistance added substantial and similar value, so here the expected costs of further development will be crucial.

Although our case focused at the improvements for vascular surgery, the framework can also be applied to other uses of the HOT. Examples are cardiovascular procedures such as transcatheter aortic valve replacement (Kaneko & Davidson, 2014) or oncological procedures (Bigot, Bouvier, Panayotopoulos, Aubé, & Azzouzi, 2016).

5.2 Limitations and future research

The effect of interdependencies was limited as the vascular surgeons did not pinpoint many interactions between the three innovations. This may been caused by the totally different nature of the technologies and the limited overlap in functionality. For other types of innovative technologies, interdependencies might manifest more clearly, and an interesting topic will be the effect of interdependencies on costs. Costs were not included in this research and could be topic of future research, since combining technologies is likely to increase development costs in this context. The combination of technologies proved to be difficult to score, as the combined scores sometimes exceeded 100, or ideal performance. The vascular surgeons always reduced the combined total to a maximum of 100. Moreover, experts interpreted the expectations for the future differently, resulting in expert 2 always giving lower scores than expert 1. One explanation can be found in the fact that expert 2 also has high expectations about the development of innovative stent types (Bekken, Jongsma, de vries, & Fioole, 2014).

The current proportion of procedures has been used to determine overall value. However, in the future the ratios might change. For example, the expected increase in prevalence of diabetes (S. Wild, Roglic, Green, Sicree, & King, 2004) is likely to lead to more cases of PAOD (Ness, Aronow, & Ahn, 2000). For future research, scenarios with updated ratios in procedures could be included.

For our case study only two vascular surgeons were interviewed. This provided us with limited views of the value of the innovations, especially since both surgeons were employed at the same hospital. For a broader view, more surgeons with different affiliations could be included although this might proof laborious and time-consuming. Further improvements could be made by extending and synthesizing expert opinions with clinical or modeled data when these become available.

6. CONCLUSION

The current speed at which healthcare innovations are being developed requires a structured and fast evaluation method that can be applied during the development process, to avoid costly development and implementation errors. This framework supports such evaluation and allows prioritization of those innovations expected to be most valuable.

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APPENDIX 1: OVERVIEW OF WEIGHT FACTORS, PERFORMANCE SCORES AND VALUES

POAD		Alternative 0						Alternative 1						Alternative 2						Alternative 3					
		Current Hybrid OR Medisch Spectrum						Alternative 0 + Wound perfusion						Alternative 0 + Continous						Alternative 0 + Steering assistance					
		Given score (0-100)						Given score (0-100)						Given score (0-100)						Given score (0-100)					
	Weights	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg
Efficiency of procedure	17	60	10,0	40	6,7	50	8,3	80	13,3	90	15,0	85	14,2	60	10,0	50	8,3	55	9,2	70	11,7	50	8,3	60	10,0
Financial effect of recovery	21	60	12,8	20	4,3	40	8,5	90	19,2	80	17,1	85	18,1	70	14,9	30	6,4	50	10,7	70	14,9	20	4,3	45	9,6
Ionizing radiation	5	80	3,7	50	2,3	65	3,0	90	4,2	50	2,3	70	3,3	80	3,7	60	2,8	70	3,3	90	4,2	50	2,3	70	3,3
Iodine contrast	20	60	12,0	45	9,0	52,5	10,5	80	16,0	45	9,0	62,5	12,5	100	20,0	100	20,0	100	20,0	80	16,0	45	9,0	62,5	12,5
Clinical success	27	40	10,7	40	10,7	40	10,7	80	21,3	80	21,3	80	21,3	50	13,3	50	13,3	50	13,3	60	16,0	60	16,0	60	16,0
Ergonomy of procedure	11	50	5,3	0	0,0	25	2,7	50	5,3	0	0,0	25	2,7	50	5,3	10	1,1	30	3,2	80	8,5	50	5,3	65	6,9
Value			**55**		**33**		**44**		**79**		**65**		**72**		**67**		**52**		**60**		**71**		**45**		**58**

(F)EVAR		Alternative 0						Alternative 1						Alternative 2						Alternative 3					
		Current Hybrid OR Medisch Spectrum						Alternative 0 + Wound perfusion						Alternative 0 + Continous						Alternative 0 + Steering assistance					
		Given score (0-100)						Given score (0-100)						Given score (0-100)						Given score (0-100)					
	Weights	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	BG	v_E1	RM	v_E2	Average	v_avg
Efficiency of procedure	19	80	15,1	70	13,2	75	14,2	80	15,1	70	13,2	75	14,2	80	15,1	75	14,2	77,5	14,7	90	17,0	80	15,1	85	16,1
Financial effect of recovery	23	70	16,3	40	9,3	55	12,8	70	16,3	40	9,3	55	12,8	75	17,5	60	14,0	67,5	15,7	90	21,0	50	11,6	70	16,3
Ionizing radiation	4	80	3,0	80	3,0	80	3,0	80	3,0	80	3,0	80	3,0	80	3,0	100	3,8	90	3,4	90	3,4	85	3,2	87,5	3,3
Iodine contrast	16	70	11,0	80	12,5	75	11,7	70	11,0	80	12,5	75	11,7	100	15,7	85	13,3	92,5	14,5	80	12,5	80	12,5	80	12,5
Clinical success	33	70	23,4	40	13,4	55	18,4	70	23,4	40	13,4	55	18,4	80	26,8	40	13,4	60	20,1	90	30,1	50	16,7	70	23,4
Ergonomy of procedure	5	80	3,9	25	1,2	52,5	2,5	80	3,9	25	1,2	52,5	2,5	80	3,9	30	1,5	55	2,7	90	4,4	50	2,4	70	3,4
Value			**73**		**53**		**63**		**73**		**53**		**63**		**82**		**60**		**71**		**88**		**62**		**75**

TEVAR		Alternative 0						Alternative 1						Alternative 2						Alternative 3					
		Current Hybrid OR Medisch Spectrum						Alternative 0 + Wound perfusion						Alternative 0 + Continous						Alternative 0 + Steering assistance					
		Given score (0-100)						Given score (0-100)						Given score (0-100)						Given score (0-100)					
	Weights	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	BG	v_E1	RM	v_E2	Average	v_avg
Efficiency of procedure	20	80	15,9	70	13,9	75	14,9	80	15,9	70	13,9	75	14,9	80	15,9	75	14,9	77,5	15,4	90	17,9	80	15,9	85	16,9
Financial effect of recovery	22	80	17,3	40	8,7	60	13,0	80	17,3	40	8,7	60	13,0	85	18,4	60	13,0	72,5	15,7	90	19,5	60	13,0	75	16,3
Ionizing radiation	5	80	4,3	80	4,3	80	4,3	80	4,3	80	4,3	80	4,3	80	4,3	100	5,4	90	4,9	95	5,1	85	4,6	90	4,9
Iodine contrast	9	70	6,0	80	6,9	75	6,5	70	6,0	80	6,9	75	6,5	100	8,6	85	7,3	92,5	8,0	80	6,9	85	7,3	82,5	7,1
Clinical success	38	80	30,3	40	15,2	60	22,8	80	30,3	40	15,2	60	22,8	85	32,2	45	17,1	65	24,7	90	34,1	60	22,8	75	28,4
Ergonomy of procedure	6	80	5,2	25	1,6	52,5	3,4	80	5,2	25	1,6	52,5	3,4	80	5,2	30	1,9	55	3,6	90	5,8	50	3,2	70	4,5
Value			**79**		**51**		**65**		**79**		**51**		**65**		**85**		**60**		**72**		**89**		**67**		**78**

Table 6: Overview of weights, scores and values for alternatives 0-3. E1 = Expert 1. v_E1 = value by Expert 1. E2 = Expert 2. v_E2 = value by Expert 2. v_avg = average value.

POAD		Alternative 4						Alternative 5						Alternative 6						Alternative 7					
		Alternatives 0 + 1 + 2						Alternatives 0 + 1 + 3						Alternatives 0 + 2 + 3						Alternative 0 + 1 + 2 + 3					
		Given (adjusted) score (0-100)						Given (adjusted) score (0-100)						Given (adjusted) score (0-100)						Given (adjusted) score (0-100)					
	Weights	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg
Efficiency of procedure	17	80	13,3	100	16,7	90	15,0	90	15,0	100	16,7	95	15,8	90	15,0	60	10,0	75	12,5	90	15,0	100	16,7	95	15,8
Financial effect of recovery	21	100	21,3	90	19,2	95	20,3	100	21,3	80	17,1	90	19,2	80	17,1	30	6,4	55	11,7	100	21,3	90	19,2	95	20,3
Ionizing radiation	5	90	4,2	60	2,8	75	3,5	90	4,2	50	2,3	70	3,3	90	4,2	60	2,8	75	3,5	100	4,7	60	2,8	80	3,7
Iodine contrast	20	100	20,0	100	20,0	100	20,0	90	18,0	45	9,0	67,5	13,5	100	20,0	100	20,0	100	20,0	100	20,0	100	20,0	100	20,0
Clinical success	27	80	21,3	90	24,0	85	22,7	100	26,7	100	26,7	100	26,7	70	18,7	70	18,7	70	18,7	100	26,7	100	26,7	100	26,7
Ergonomy of procedure	11	50	5,3	10	1,1	30	3,2	80	8,5	50	5,3	65	6,9	80	8,5	60	6,4	70	7,5	80	8,5	60	6,4	70	7,5
Value			**85,5**		**83,7**		**85**		**93,7**		**77,1**		**85**		**83,5**		**64,3**		**74**		**96,2**		**91,7**		**94**

(F)EVAR		Alternative 4						Alternative 5						Alternative 6						Alternative 7					
		Alternatives 0 + 1 + 2						Alternatives 0 + 1 + 3						Alternatives 0 + 2 + 3						Alternative 0 + 1 + 2 + 3					
		Given (adjusted) score (0-100)						Given (adjusted) score (0-100)						Given (adjusted) score (0-100)						Given (adjusted) score (0-100)					
	Weights	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg
Efficiency of procedure	19	80	15,1	75	14,2	77,5	14,7	90	17,0	80	15,1	85	16,1	90	17,0	85	16,1	87,5	16,6	90	17,0	85	16,1	87,5	16,6
Financial effect of recovery	23	75	17,5	60	14,0	67,5	15,7	90	21,0	50	11,6	70	16,3	95	22,1	70	16,3	82,5	19,2	95	22,1	70	16,3	82,5	19,2
Ionizing radiation	4	80	3,0	100	3,8	90	3,4	90	3,4	85	3,2	87,5	3,3	95	3,6	100	3,8	97,5	3,7	95	3,6	100	3,8	97,5	3,7
Iodine contrast	16	100	15,7	85	13,3	92,5	14,5	80	12,5	80	12,5	80	12,5	100	15,7	85	13,3	92,5	14,5	100	15,7	85	13,3	92,5	14,5
Clinical success	33	80	26,8	40	13,4	60	20,1	90	30,1	50	16,7	70	23,4	100	33,5	50	16,7	75	25,1	100	33,5	50	16,7	75	25,1
Ergonomy of procedure	5	80	3,9	30	1,5	55	2,7	90	4,4	50	2,4	70	3,4	90	4,4	55	2,7	72,5	3,5	90	4,4	55	2,7	72,5	3,5
Value			**82,0**		**60,1**		**71**		**88,4**		**61,7**		**75**		**96,3**		**68,9**		**83**		**96,3**		**68,9**		**83**

TEVAR		Alternative 4						Alternative 5						Alternative 6						Alternative 7					
		Alternatives 0 + 1 + 2						Alternatives 0 + 1 + 3						Alternatives 0 + 2 + 3						Alternative 0 + 1 + 2 + 3					
		Given (adjusted) score (0-100)						Given (adjusted) score (0-100)						Given (adjusted) score (0-100)						Given (adjusted) score (0-100)					
	Weights	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg	E1	v_E1	E2	v_E2	Average	v_avg
Efficiency of procedure	20	80	15,9	75	14,9	77,5	15,4	90	17,9	80	15,9	85	16,9	90	17,9	85	16,9	87,5	17,4	90	17,9	85	16,9	87,5	17,4
Financial effect of recovery	22	85	18,4	60	13,0	72,5	15,7	90	19,5	60	13,0	75	16,3	95	20,6	80	17,3	87,5	19,0	95	20,6	80	17,3	87,5	19,0
Ionizing radiation	5	80	4,3	100	5,4	90	4,9	95	5,1	85	4,6	90	4,9	95	5,1	100	5,4	97,5	5,3	95	5,1	100	5,4	97,5	5,3
Iodine contrast	9	100	8,6	85	7,3	92,5	8,0	80	6,9	85	7,3	82,5	7,1	100	8,6	90	7,8	95	8,2	100	8,6	90	7,8	95	8,2
Clinical success	38	85	32,2	45	17,1	65	24,7	90	34,1	60	22,8	75	28,4	95	36,0	65	24,7	80	30,3	95	36,0	65	24,7	80	30,3
Ergonomy of procedure	6	80	5,2	30	1,9	55	3,6	90	5,8	50	3,2	70	4,5	90	5,8	55	3,6	72,5	4,7	90	5,8	55	3,6	72,5	4,7
Value			**84,7**		**59,7**		**72**		**89,4**		**66,8**		**78**		**94,1**		**75,6**		**85**		**94,1**		**75,6**		**85**

Table 7: Overview of weights, scores and values for alternatives 4-7. E1 = Expert 1. v_E1 = value by Expert 1. E2 = Expert 2. v_E2 = value by Expert 2. v_avg = average value.