Value-based healthcare in colorectal cancer surgery : improving quality and reducing costs

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CHAPTER 4

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COSTS OF COMPLICATIONS AFTER COLORECTAL CANCER SURGERY IN THE NETHERLANDS: BUILDING THE BUSINESS CASE FOR HOSPITALS

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ABSTRACT

Background

Healthcare providers worldwide are struggling with rising costs while hospitals budgets are under stress. Colorectal cancer surgery is commonly performed, however it is associated with a disproportionate share of adverse events in general surgery. Since adverse events are associated with extra hospital costs it seems important to explicitly discuss the costs of complications and the risk factors for high-costs after colorectal surgery.

Methods

Retrospective analysis of clinical and financial outcomes after colorectal cancer surgery in 29 Dutch hospitals (6768 patients). Detailed clinical data was derived from the 2011-2012 population-based Dutch Surgical Colorectal Audit database. Costs were measured uniform in all participating hospitals and based on Time-Driven Activity-Based Costing.

Findings

Of total hospital costs in this study, 31% was spent on complications and the top 5% most expensive patients were accountable for 23% of hospitals budgets. Minor and severe complications were respectively associated with a 26% and 196% increase in costs as compared to patients without complications. Independent from other risk factors, ASA IV, double tumor, ASA III, short course preoperative radiotherapy and TNM-4 stadium disease were the top-5 attributors to high costs.

Conclusions

This article shows that complications after colorectal cancer surgery are associated with a substantial increase in costs. Although not all surgical complications can be prevented, reducing complications will result in considerable cost savings. By providing a business case we show that investments made to develop targeted quality improvement programs will pay off eventually. Results based on this study should encourage healthcare providers to endorse quality improvement efforts.

INTRODUCTION

Nowadays, healthcare providers worldwide are struggling with rising costs while hospitals budgets are under stress. In response to the current demand for financial transparency, it seems important to explicitly discuss underlying costs of services provided. Earlier studies showed that hospital costs are associated with quality of healthcare where hospitals providing high quality care have lower costs [12]. Postoperative complications lead to increased resource utilization and as a consequence to higher healthcare costs [3-9]. Therefore more and more pressure is being exerted on health care providers to simultaneously improve quality and reduce costs of health care provided.

Colorectal cancer surgery is a commonly performed procedure, but remains associated with high postoperative morbidity and mortality and accounts for an extraordinary share of adverse events in general surgery [10]. In the Netherlands, roughly 10000 colorectal cancer procedures are performed every year [11]. As of 2009, detailed patient and outcome characteristics of colorectal surgery are registered in the nationwide Dutch Surgical Colorectal Audit (DSCA) to monitor, evaluate and improve colorectal cancer care[11,12]. In order to facilitate improvement initiatives aiming for a decrease in healthcare costs by reducing complications, the primary objective of the current study was to explore the association between complications after colorectal cancer surgery and hospital costs. To analyze the financial impact of complications also after hospitalization, we included hospitals costs up to 90 days after discharge. A secondary aim of the present study was to investigate the existence of common risk factors for complications and their associated costs.

PATIENTS AND METHODS

Clinical data

The data set was retrieved from the Dutch Surgical Colorectal Audit (DSCA) a nationwide, population based database where detailed patient, tumor, diagnostic,

procedural and outcome data are registered for patients who undergo a resection of a primary colorectal carcinoma in the Netherlands. The dataset shows a nearly 100% completeness on most items and high accuracy level of validation compared to the Netherlands Cancer Registry [11,12]. A detailed description of the DSCA has been published recently [12,13].

Financial data

The economic evaluation was conducted from a hospital perspective. Therefore only 'in-hospital' costs were considered in this study. Costs were taken into account from the day of initial surgery till discharge (= primary admission) up to 90 days after discharge (= Q1). Resource utilization at patient level was extracted from the Hospital Information System from each participating hospital. For each hospital, translation of patient level resource utilization into costs was provided by Performation (Bilthoven, The Netherlands), which is a healthcare consultancy firm providing patient level costing and benchmarking products for more than 100 hospitals across Europe [14,1516]. Costs were calculated by using Time-Driven Activity-Based Costing (TD-ABC) methodology [17] which is an advanced method for understanding hospitals costs[18]. Cost price calculations are standardized by Performation and therefore uniformity in methodology exists between all participating hospitals. The most recent cost price model of 2012 for each hospital was used for both years (2011 and 2012) to avoid differences due to inflation or to the different models themselves. Different activities are grouped into eight categories as shown in Supplemental Table 1. All activities consisted of direct (e.g. personnel staff, material and equipment) and indirect costs. For example, direct costs for an inpatient day (category 'ward') consisted of (a) personnel as salary of ward nurses and administrative personnel, (b) material costs as bed linen and bandages and (c) depreciation of equipment such as ward inventory. Examples of indirect costs are those related to information technology, building depreciation, cleaning, catering, etc. Specialists' fees, medication and dialyses costs were excluded since registration of these parameters was not uniform in all participating hospitals making equal comparison impossible.

Inclusion criteria

Hospital selection (n = 29) was based on the availability of detailed cost-price information for two consecutive years. In these hospitals approximately a third of the entire colorectal cancer surgery procedures annually performed in the Netherlands was carried on. From the 29 hospitals, 21 (72%) have a surgical teaching program. Patients undergoing surgical resection for primary colorectal cancer between January 1st, 2011 and December 31st, 2012 had to be registered in the DSCA before December 1st 2013. Minimal data requirements to consider a patient eligible for matching with the financial dataset was information concerning tumor location, date of surgery and mortality status.

Match

Unique Patient Identification Number (UPIN) combined with hospital of admission was used to match patients registered in the DSCA to their information in the financial database. For those without a match on UPIN four different patient characteristics were matched (date of birth, gender, hospital of admission and date of surgery). This method resulted in a data set of 6782 eligible patients (match > 99%).

Definitions

Two different methods of analyzing complications were used. The first method divided complications into two groups as described earlier [19,20]: (1) mild complications, defined as any complication occurring within 30 days after resection and not being a severe complication and (2) severe complications, defined as a complication with serious consequences: leading to mortality, a reintervention (operative or percutaneous), or a postoperative hospital stay of at least 14 days. Any patient not having a mild or severe complication was analyzed as 'no complication'. The second method classifies complications in 7 categories: (1) surgical complications, (2) pulmonary complications, defined as a complication mainly related to the lung (except for pulmonary embolism), e.g. bacterial pneumonia or viral pneumonia. (3) Cardiac complications, defined as a complication which cause is related to the heart, e.g. cor pulmonale or myocardial infarction. (4) Neurologic complications, defined as

a complication which cause is related to the nerve system or brain, e.g. cerebrovascular accident. (5) Infectious complications defined as any infection other than surgical infection or pneumonia, e.g. urinary tract infection. (6) Thromboembolic complications, defined as a complication which cause is related to the blocking of a blood vessel due to the formation of a blood clot (except for cerebral accidents), e.g. pulmonary embolism or deep vein thrombosis. (7) Other complications, defined as any complication not listed in any of the categories above. Outcome measures for costs of healthcare were (1) hospital costs of primary admission, (2) hospital costs after discharge up to 90 days (= Q1), (3) total hospital costs (= hospital costs of primary admission and Q1) (4) length of hospital stay, (5) length of intensive care (IC) stay and (6) operation time.

Statistical analyses

Chi-square test and one-way Anova were used to investigate differences between patients' characteristics (Table 1).

Three different analyses were performed in this study. In the first analysis cost differences between patients with none-, mild- or severe complications were analyzed. Costs were calculated for primary admission, first 90 days after discharge (Q1) and total costs (primary admission and Q1). Mixed model with hospitals as random effects were used to account for the presence of possible variability between hospitals and are designed to handle nested data (like patients in each hospital) and unequal group study [21,22].

The second method analyzed differences in total costs (primary admission and Q1) among 7 categories of complications by using multivariate regression models with hospitals as random effects. First, the analysis was performed without risk-adjustment; then with risk-adjustment for patient's characteristics illustrated in Table 1; in the last analysis risk-adjustment for patient's characteristics and all type of complications were included in the mixed model. Only patients' characteristics that did not depend on choices made by a surgeon were used for the risk-adjustment model (therefore surgical approach and construction of a stoma were not used for risk-adjustment) (Table 1).

In the third analysis risk factors (patient characteristics listed in Table 1) associated with severe complications and total costs (primary admission and Q1) were investigated by using multivariate regression models with hospitals as random effects. Statistical analyses were performed by using SPSS (version 20; IBM) and R (version 18). Outcomes are presented as the mean. Confidence intervals (CI) were stated at 95%.

RESULTS

A total of 6782 patients were eligible for analysis. 819 patients (12.1%) suffered from mild complications, 1426 patients (21.0%) suffered from severe complications. All analyzed patient, tumor and procedural characteristics of the studied population are shown in Table 1.

Distribution of costs and additional costs of complications

Patients were grouped as 2.5% (n = 170) of the whole analyzed population: average total costs (primary admission and Q1) for patients ranged from €3403 (least expensive 2.5%) to €79953 (most expensive 2.5%). The top 5% most expensive patients were accountable for 23% of the total hospital costs analyzed in this study (Figure 1A). Highest total costs for one single patient was €205946.

Total hospital costs (primary admission and Q1) of our studied population was €90.308 million (100%). Average costs for one patient without complications was €9226. This resulted in €62.569 million (69%) in 'baseline' costs (€9226 X 6782 patients). Patients with mild and severe complications were respectively associated with €1.984 million (2%) and €25.755 million (29%) additional costs (Figure 1B).

Table 1. Patient, tumor and treatment characteristic of patients enrolled in this study with no, mild or severe complications

		Total		No complication		Mild complication		Severe complication		
		N	%	N	%	N	%	N	%	*p*-value
Total		6782		4537	66.9%	819	12.1%	1426	21.0%	
Characteristics for risk-adjustment										
Sex	Male	3734	55.1%	2357	52.0%	491	60.0%	886	62.1%	<0.001
BMI (mean)		26.2		26.07		26.41		26.33		0.038
Age (mean)		69.8		69.14		70.47		71.40		<0.001
Charlson score	Charlson 0	3621	53.4%	2534	55.9%	438	53.5%	649	45.5%	<0.001
	Charlson 1	1544	22.8%	1013	22.3%	194	23.7%	337	23.6%	
	Charlson 2+	1617	23.8%	990	21.8%	187	22.8%	440	30.9%	
ASA score	I-II	5092	75.1%	3587	79.3%	601	74,0%	904	63.7%	<0.001
	III	1558	23.0%	893	19.7%	204	25.1%	461	32.5%	
	IV-V	105	1.5%	44	1.0%	7	0.9%	54	3.8%	
Double tumor	Yes	247	3.6%	148	3.3%	27	3.3%	72	5.0%	0.006
Tumor location	Right colon	2150	31.7%	1464	32.3%	258	31.5%	428	30.0%	<0.001
	Left colon	795	11.7%	529	11.7%	89	10.9%	177	12.4%	
	Sigmoid	1810	26.7%	1285	28.3%	192	23.4%	333	23.4%	
	Rectum	2027	29.9%	1259	27.7%	280	34.2%	488	34.2%	
Tumor stage (TNM)	Stadium unknown	125	1.8%	97	2.2%	9	1.1%	19	1.3%	0.005
	Stadium 0	156	2.3%	108	2.4%	18	2.2%	30	2.1%	
	Stadium 1	436	6.4%	319	7.1%	47	5.8%	70	5.0%	
	Stadium 2	1408	20.8%	930	20.6%	170	20.9%	308	21.9%	
	Stadium 3	3723	54.9%	2494	55.3%	468	57.4%	761	54,0%	
	Stadium 4	887	13.1%	563	12.5%	103	12.6%	221	15.7%	

Table 1. Patient, tumor and treatment characteristic of patients enrolled in this study with no, mild or severe complications (continued)

		Total		No complication		Mild complication		Severe complication		
		N	%	N	%	N	%	N	%	*p*-value
Preoperative radiotherapy	None	5051	74.5%	3483	76.8%	571	69.7%	997	69.9%	<0.001
	5 x 5 Gy	941	13.9%	547	12.1%	134	16.4%	260	18.2%	
	60 Gy / else	790	11.6%	507	11.2%	114	13.9%	169	11.9%	
Distant metastases	Yes	705	10.4%	459	10.1%	83	10.1%	163	11.4%	0.354
Metastasectomy	Yes	227	3.3%	142	3.1%	29	3.5%	56	3.9%	0.326
Extended resections	Yes	572	8.4%	360	7.9%	83	10.1%	129	9.0%	0.073
Urgency of resection	Urgent	902	13.3%	525	11.6%	114	13.9%	263	18.5%	<0.001
Other characteristics										
Surgical approach	Laparoscopic	3352	49.4%	2456	54.2%	329	40.2%	567	39.8%	<0.001
Anastomosis or stoma	Anastomose	4261	62.8%	3035	69.8%	458	58.7%	768	55.7%	<0.001
	Anastomose & stoma	903	13.3%	514	11.8%	120	15.4%	269	19.5%	
	Stoma	1347	19.9%	802	18.4%	202	25.9%	343	24.9%	

Abbreviations: CI, 95% confidence interval; BMI, Body Mass Index; ASA, American Society of Anesthesiologists risk score; Left colon, including transverse colon; TNM, Classification of Malignant Tumors; Gy, gray. Statistical analyses performed using Chi-square test or one-way Anova.

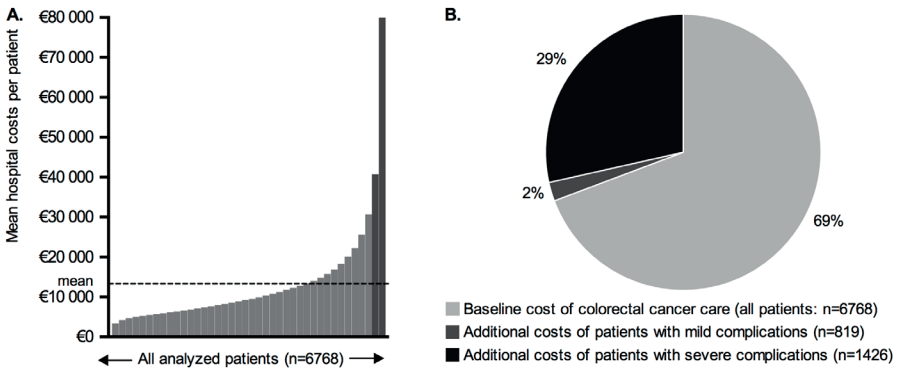


Figure 1. Illustrative picture: Distribution of costs and additional costs of patients with complications
A. Each bar represents mean costs of 2,5% (170 patients) of the analyzed patients in this study. Top 5% most expensive patients (two dark grey bars) are accountable for 23% of the total costs.
B. Baseline costs are accountable for 69% (€62 million) of total hospital costs. Patients with mild and severe complications are respectively accountable for 2% (€2 million) and 29% (€26 million) additional costs.

Minor and severe complications

Costs related to primary admission only were higher for patients with minor (€9061) and severe complications (€23616) as compared to patients without complications (€7470). Using the mixed model with hospitals as random effects costs significant increased for patients with minor and severe complications with respectively €1623 (CI €795: €2451, $p < 0.001$) and €16059 (CI €15401: €16716, $p < 0.001$).
Costs related to the first 90 days after discharge were higher for patients with minor (€2587) and severe complications (€3671) as compared to patients without complications (€1756). Using the mixed model with hospitals as random effects costs significantly increased for patients with minor and severe complications with respectively €799 (CI €415: €1183, $p < 0.001$) and €1869 (CI €1564: €2174, $p < 0.001$) (Figure 2).

For total hospital costs (primary admission and Q1) minor complications were associated with a significant 26% increase in costs. Using the mixed model with hospitals as random effects costs significantly increased with €2403 (CI €1497: €3309, $p < 0.001$). This increase mainly depended on higher costs in the categories ward, intensive care and operation (Table 2A).

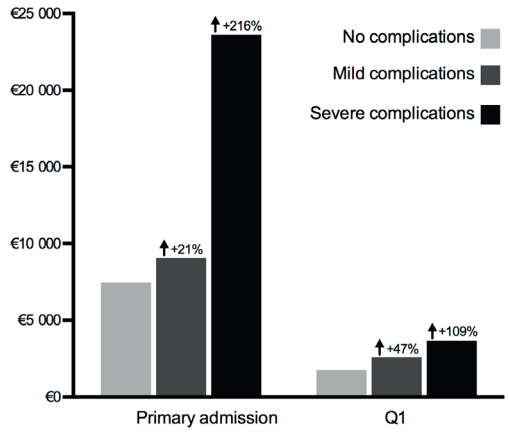


Figure 2. Increase in costs for colorectal cancer patients with a complicated course
Average costs per patient of primary admission and Q1 (=first 90 days after discharge). Arrow represents difference as compared to 'no complications'.

Major complications were associated with an even higher increase (= 196%) in costs. Using the mixed model with hospitals as random effects costs significantly increased with €17906 (CI €17189: €18623, $p < 0.001$). This increase mainly depended on higher costs in the categories intensive care, ward and operation (Table 2A).
Patients suffering minor complications and major complications had longer total operation time, hospital stay and Intensive Care stay (Table 2B).

Table 2a. Detailed overview of costs of complications

	No complication	Minor complication	Major complication
n	4527	819	1422
Categories			
Operation	€ 3492	€ 3674	€ 4912
Ward	€ 3653	€ 4957	€ 8593
Intensive care	€ 670	€ 1025	€ 9167
Radiology	€ 148	€ 239	€ 558
Laboratory	€ 480	€ 609	€ 1749
Consulting	€ 338	€ 453	€ 630
Materials	€ 107	€ 185	€ 550
Other	€ 339	€ 505	€ 1128
Total	**€ 9226**	**€ 11648**	**€ 27287**

Table 2b. Attributers of costs

	No complication	Minor complication	Major complication
n	4527	819	1422
Attributers			
Operation time (hour)	3.01	3.22	3.32
Hospital LOS (days)*	10.29	13.97	28.60
IC LOS (days)	0.40	0.59	4.95

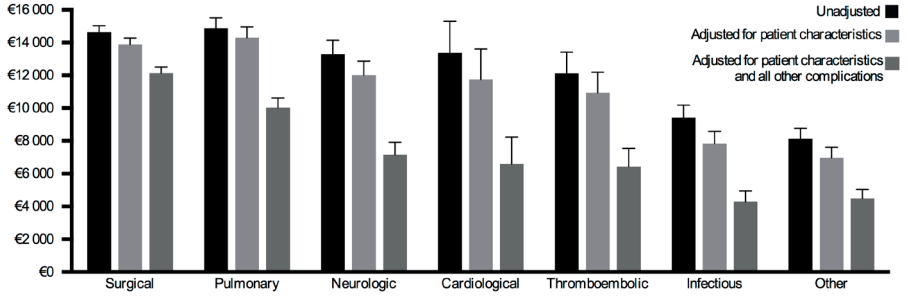
Data is shown from day of primary surgery up to 90 days after discharge (therefore costs/ hours/ days associated with re-hospitalizations or re-operations up to 90 days after discharge are included). Abbreviations: LOS, length of stay; IC, intensive care. * Including IC days.

Specific complications

All types of complications were associated with large increase in hospital costs, compared with those without complications. Most common complications were surgical complications (n = 1347, 19.9%). The largest increase in unadjusted costs was seen for pulmonary complications (n = 465, €14873, CI €13603: €16144, p < 0.001). After risk-adjustment for patient characteristics pulmonary complications were still associated with the largest attributable costs as well (=€14308, CI €13050: €15565, p < 0.001). After risk-adjustment, for patient characteristics and for other complications, surgical complications were associated with the largest attributable costs (= €12131, CI €11398: €12863, p < 0.001) (Figure 3). In detail, patients suffering from an anastomotic leakage (n= 468, €33486) were almost 3 times more expensive than patients without an anastomotic leakage (n = 6314, €11821).

Patients' characteristics associated with clinical and financial outcomes

Independent from other risk factors, the strongest association with severe complications was seen for ASA IV-V (OR 3.998, CI 2.582:6.188, p < 0.001), urgent resections (OR 1.886, CI 1.554:2.289, p < 0.001) and 5 x 5 Gray preoperative radiotherapy (OR 1.809, CI 1.318:2.482, p < 0.001). Independent from other risk factors, the strongest association with increased costs was seen for ASA IVV patients (RC €7264, CI €4355: €10172, p < 0.001), patients with synchronous tumors (RC €3302, CI €1388: €5215, p = 0.001) and ASA III patients (RC €3295, CI €2327: €4266, p < 0.001) (Figure 4).



Attributable increase with complication*

Complication	n		Unadjusted	95% CI		Adjusted for patient characteristics	95% CI		Adjusted for patient characteristics and all other complications	95% CI	
Surgical	1347	19.9%	**€ 14638**	€ 13875	€ 15401	**€ 13894**	€ 13142	€ 14646	**€ 12131**	€ 11398	€ 12863
Pulmonary	465	6.9%	**€ 14873**	€ 13603	€ 16144	**€ 14308**	€ 13050	€ 15565	**€ 10024**	€ 8858	€ 11189
Cardiological	271	4.0%	**€ 13290**	€ 11621	€ 14959	**€ 12014**	€ 10353	€ 13675	**€ 7156**	€ 5660	€ 8653
Thromboembolic	52	0.8%	**€ 13363**	€ 9576	€ 17151	**€ 11739**	€ 8073	€ 15404	**€ 6598**	€ 3374	€ 9823
Neurologic	117	1.7%	**€ 12120**	€ 9578	€ 14662	**€ 10931**	€ 8454	€ 13408	**€ 6424**	€ 4233	€ 8615
Infectious	353	5.2%	**€ 9424**	€ 7940	€ 10908	**€ 7843**	€ 6389	€ 9297	**€ 4290**	€ 2998	€ 5583
Other	502	7.4%	**€ 8124**	€ 6860	€ 9389	**€ 6977**	€ 5739	€ 8215	**€ 4485**	€ 3389	€ 5582

Figure 3. Relationship of complications after colorectal surgery to unadjusted and adjusted hospital costs Attributable increase in costs with complication is shown. In graph std. error is shown. *P-values for all attributable costs were <0.001.

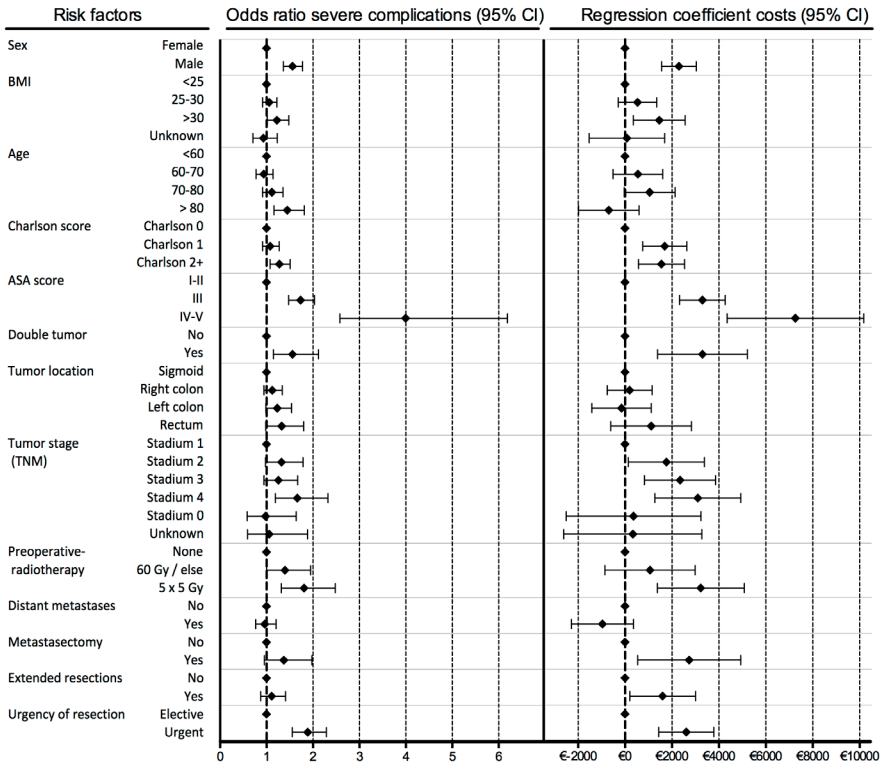


Figure 4. Risk factors associated with severe complications and costs of those severe complications
Risk factors (patient characteristics listed in Table 1) associated with severe complications and total costs (primary admission and Q1) were investigated by using multivariate regression models with hospitals as random effects. Abbreviations: BMI, Body Mass Index; ASA, American Society of Anesthesiologists risk score; Left colon, including transverse colon; TNM, Classification of Malignant Tumors; Gy, gray.

DISCUSSION

This is the first European multicenter study providing a detailed estimate of hospital costs associated with adverse events in colorectal cancer surgery. In addition this report shows that almost a quarter of hospitals budget for colorectal cancer surgery is spend on a relatively small percentage of patients and almost a third of hospitals budget is spend on treating complications. Our report highlights that risk factors for severe complications are associated with high costs as well. Since more

and more pressure is being exerted on health care providers to simultaneously improve quality and reduce the costs of the provided care, the conclusions based on this article should catalyze the development of targeted quality improvement programs.

Complications after colorectal cancer surgery in this report were common and occurring after 33% of the procedures performed. In the studied population, 12% had mild complications and 21% had severe complications which is comparable with an earlier study using data from the American College of Surgeons National Surgical Quality Improvement Program (29% of adverse events) [10]. The average costs of colorectal patients (and their complications) in our study are consistent with earlier studies as well[3], however we provide this evidence based on detailed clinical and financial data. In addition to the existing literature, this study has some major advantages. Our results are based on multi-center data, which gives a more comprehensive perspective as publication bias of individual 'well performing' hospitals [3-5] is avoided. Instead of using insurance claim data to calculate costs [7,9] this study was performed from a hospitals perspective using TD-ABC methodology, which is a superior method for measuring and understanding costs [17,18]. Clinical data was retrieved from the detailed DSCA dataset, therefore enabling accurate risk-adjustment [13]. Moreover, since the DSCA is a population-based registry, the data was not hampered by overrepresentation of a specific group of patients (Table 1). In contrast, two recent multi-center studies from the United States analyzing costs of complications retrieved their data from Veterans Affairs hospitals [6,8]. Almost 95% of their analyzed patients were male which is a major risk factor for complications itself [23] and consequently a risk factor for increased costs (Figure 4). Surgical complications were most common after colorectal cancer surgery and were, independent from differences in patient characteristics and other complications, associated with the highest increase in hospital costs (Figure 3). After adjustment for other complications, strongest decrease in additional costs was seen for thromboembolic complications (reduction of €5141). This suggests that thromboembolic complications often occur at the same time with other complications.

To create more insight in the relation between severe complications and the costs of severe complications we analyzed risk factors for severe complications and

hospital costs. For almost every risk factor associated with the development of severe complications, a similar trend was seen for developing high hospital costs. This means that patients with a high risk for complications are a risk for generating high hospital costs as well. ASA IV-V, short course radiotherapy, ASA III and TNM-stage 4 were top-5 risk factors for both developing severe complications as well as high hospital costs (Figure 4). Remarkable is the inverse relationship between severe complications and costs for patients older than 80 years. As compared to patients under 60 years and independently from other risk factors, octogenarians were associated with a significant increased risk for developing severe complications (OR 1.449, CI 1.158:1.812, p = 0.001) though associated with a decrease in hospital costs (RC €-691, CI €-1984: €601, p = 0.29). Nevertheless, when looking at unadjusted averages, octogenarians were still associated with slightly higher costs as compared to patients under 60 years (data not shown). This means that high age itself (> 80 years) is not associated with higher hospital costs though comorbidities (or other patient characteristics) of octogenarians are.

Limitations

This study has some limitations. First of all one might argue that in their attempts to achieve lower complication rates, participants might not register patients with complications. Also under-registration of complications themselves might happen, in order to achieve lower complication rates. However, registration of surgical colorectal cancer patients in the DSCA is a National Performance Indicator [12], resulting in high completeness of the DSCA as compared to the National Cancer Registry [11]. We also looked in detail to hospital costs of patients without complications; outliers in costs were hardly seen, making this under-registration less plausible. Second, some costs are not likely to be affected by a reduction of complications in the short term, like overhead costs and staffing. Therefore, assuming a direct relationship between a single complication and costs may not be appropriate. Third, a direct relationship between the introduction of clinical auditing for colorectal cancer surgery in the Netherlands and the marked reduction of complications can hardly be proven. The introduction of laparoscopic surgery in many hospitals, or other secular trends registered in the audit or not, may have lead to an improve-

ment in quality of care itself. Nevertheless, without availability of key data on outcomes, health care organizations are flying blind in deciding what should be targets for quality improvement initiatives. Moreover, combining key outcome data with accurate financial outcomes should be the cornerstone of developing an affordable health care system [18].

The business case

An addition to studies from the United States describing costs of complications after surgery [5,6,8] is the specific selection of colorectal cancer patients analyzed in this study. Those earlier studies analyzed a broad variation of general (and/or vascular) surgical procedures, which makes their conclusions harder to implement for targeted improvement programs. As described by Schilling et al. colon surgery is associated with a disproportional share of complications in general surgery. Representing only 10% of the analyzed procedures in their study, colon surgery was responsible for almost 25% of the complications [10]. Obviously, a decline in complication rates after colorectal surgery will be of most benefit to the patients, however one might argue that a business case for quality improvement can be made for hospitals as well [24]. Described by an earlier study of our group, severe complication rates after implementation of a nationwide colorectal surgical audit dropped from 25% in 2010 to 20% in 2012 [2]. If a hospital performed an average of 100 colorectal cancer procedures per year and had an average severe complication rate in 2010 of 25%, an annual reduction in severe complications of 10% may lead to a saving of €120000 in 2012 as compared to 2010 (1 major complication is associated with €16059 of additional costs, Supplemental Table 2). A reduction of complications can only be achieved when key data regarding clinical outcomes is available, identifying areas for targeted quality improvement programs. Since this is a cost and time consuming exercise [25] we also calculated the costs for participation in the DSCA for this exampled hospital (Supplemental Table 3). If yearly costs for participation (€13350) were incorporated in the analysis as well, overall profit after three years for this single hospital would be more then €80000 (Supplemental Table 2). This should be a strong incentive for healthcare providers to support

and develop targeted quality improvement programs in order to simultaneously improve quality of healthcare and reduce costs.

Future perspectives

A recent study from the United States [26] described that under some payers the occurrence of surgical complications was associated with higher hospital contribution margins, therefore providing a perverse stimulus for healthcare providers. The Dutch healthcare system does not have different reimbursements for patients with or without complications, and therefore reducing complications in Dutch hospitals will directly benefit hospitals finances. A solution to overcome contra-productive reimbursement systems [26], might be the introduction of bundled payments that are tied to overall care for a medical condition [18]. Well-designed bundled payments encourage teamwork and should include severity adjustments for more complex patients (in order to compensate for potential higher costs as seen in Figure 4). Ideally, these bundled payments should hold the provider financial responsible for avoidable complications, preferable for a long period (e.g. 1 or 2 year after surgery), resulting in a strong incent to improve (long-term) outcomes for patients [18]. Providers might benefit from improving efficiency while maintaining or improving the value for patients, as seen in certain regions in Sweden [27].

CONCLUSIONS

This study shows that besides patients health care providers suffer from complications as well: tremendous increase in costs is seen for colorectal cancer patients with a complicated postoperative recovery. Key data on clinical outcomes is necessary to measure value and to identify patients at risk. Admitting that surgical audits are time and costs consuming exercises, our business case shows that investments made to develop targeted quality improvement programs will pay of eventually. Therefore conclusions based on this study should be an impetus for healthcare providers to develop and maintain targeted quality improvement programs.

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SUPPLEMENTAL MATERIAL

Supplemental Table 1. Different categories of resources extracted from the Hospital Information System

Category	Examples within category
Operation	Surgery time, operation room session
Ward	Inpatient ward days
Intensive care	Intensive Care Unit days, Medium Care Unit days, Cardiac Care Unit days
Radiology	Ultra sound, X-ray, CT scan, MRI scan
Laboratory	Activities related to pathology, haematology, clinical chemistry, microbiology
Consulting	Consults other medical specialist, outpatient department visits
Materials	Blood products, prostheses and implants
Other	Electrocardiography, spirometry, physiotherapy, medical rehabilitation

Supplemental Table 2. The business case

	2010	**2011**	**2012**	**Total**
Yearly cost of registration*	€ 13350	€ 13350	€ 13350	€ 40050
Severe complication rate (%)	25,0%	22,5%	20,0%	n/a
Potential cost saving (€)**	n/a	€ 40148	€ 80295	€ 120443
Net saving	-€ 13350	€ 26798	€ 66945	€ 80393

Potential cost saving for one hospital performing 100 colorectal cancer procedures a year. * See supplemental table 3. ** As compared to 2010 and based on €16059 of additional costs of 1 severe complication.

Supplemental Table 3. Yearly costs of clinical auditing in 2012

		Cost price	n	total
Fixed costs	Yearly hospital fee*	€ 3000	1	€ 3000
	Monthly hospital fee*	€ 300	12	€ 3600
Variable costs	Fee per patient*	€ 25	100	€ 2500
	Costs of registration**	€ 17	100	€ 1700
	Costs of verification***	€ 26	100	€ 2550
Total costs	Total per patient	€ 134	100	€ 13350

* Costs based on Dutch Surgical Colorectal Audit 2012 fee. ** Based on 30 minutes of registration by a Physician Assistant (year salary €60000). *** Based on 15 minutes of verification by a surgeon (yearly salary €180000).