Chapter six

Clinical relevance of conversion rate and its evaluation in laparoscopic hysterectomy

Twijnstra ARH[a]

Blikkendaal MD[a]

van Zwet EW

Jansen FW

[a] Shared first authorship

Accepted in J Minim Invasive Gynecol. October 2012

Abstract

Background

Objective of is study is to estimate the current conversion rate in laparoscopic hysterectomy (LH), to estimate the influence of patient, procedure and performer characteristics on conversion and to hypothesize the extent to which conversion rate can act as a means of evaluation in LH.

Materials and Methods

Prospective cohort study in 79 gynecologists representing 42 hospitals throughout the Netherlands. This reflects 75% out of all gynecologists performing LH in the Netherlands (and 68% of the hospitals). Data from 1.534 LHs were collected between 2008 and 2010.

Results

Conversion rate, odds ratios (OR) of risk factors for conversion and conversion as a means of evaluation. Conversions were discriminated as reactive or strategic. The literature reported a conversion rate in LH of 0-19% (mean 3.5%). In our cohort, 70 LHs were converted (4.6%). Using a mixed effects logistic regression model we estimated independent risk factors for conversion. BMI (p=.002), uterus weight (p<.001), type of LH (p=.004) and age (p=.023) had a significant influence on conversion. The risk of conversion was increased at BMI >35 kg/m^2 (OR 6.53, p<.001), age >65 years (OR 6.97, p=.007), uterus weight 200-500 grams (OR 4.05, p<.001) and especially >500 grams (OR 30.90, p<.001). A variation that was not explained by the covariates included in our model was identified and referred to as the 'Surgical Skills Factor' (average odds ratio 2.79, p=.001).

Conclusion

By means of the estimated risk factors (BMI, uterus weight, age and surgical skills), better insight is acquired into the risk of conversion. Conversion rate can be used as a means of evaluation to ensure better outcomes of LH for future patients.

Introduction

In order to spare women the customary and inevitable abdominal incision, laparoscopic hysterectomy (LH) was adopted twenty years ago, as a minimally invasive alternative to conventional abdominal surgery.[1]

As a result, women are protected from the increased risk of blood loss, wound infection and prolonged recovery period.[2] Yet, if laparoscopy fails, the surgeon apparently always has the possibility to 'escape' by conversion to the conventional abdominal approach. Therefore, most gynecologists are at the opinion that conversion is inherent to laparoscopy and should not be regarded as an adverse event.[3-5]

In former publications, conversion rate was used to justify the feasibility of the laparoscopic approach.[6] However, to date, conversion rates in LH are still mentioned, yet no specific conclusions are drawn from these outcomes. As one could imagine, conversion, that involves a combined exposure to the general risk of the laparoscopic approach followed by an additional laparotomy, is associated with significantly worse post-operative outcomes.[7,8] Additionally, also the indication for conversion matters. Several studies within the field of laparoscopic colorectal surgery showed that a conversion due to an intra-operative adverse event ('reactive', e.g. due to a lesion of the ureter) is associated with higher post-operative morbidity than a conversion in order to prevent an adverse event in case of operative difficulties ('preemptive' or 'strategic', e.g. due to adhesions).[9,10] As a consequence, proper documentation of a conversion and its indication is essential.

In LH, strategic conversions can occur for a number of reasons. An enlarged immobile uterus and/or severe adhesions can obstruct proficient visibility of the operating field. Furthermore, additional pathology (e.g. a more advanced stage of cancer than expected) might dictate immediate conversion to the conventional approach. Finally, patient risk factors, such as (morbid) obesity, might impede the laparoscopic approach; e.g. the anesthesiologist is challenged to such an extent that conversion is required for patient safety reasons.

Interestingly, especially this subdivision into strategic and reactive conversions can provide information on indication, patient selection and the experience and skill of the surgeon. Therefore, we hypothesize that the conversion rate may act as a means of evaluation of the 'quality' of a series of performed LHs.

Since the past decade quality assurance of the surgical process is under increasing attention. [11] With the ultimate goal to improve the quality of care, quality assurance enables evaluation and interpretation of variations in treatment, which, in turn, can be linked to treatment outcomes.[12,13]

We are at the opinion that the importance of quality assurance in minimally invasive gynecology is currently underestimated. Given the fact that in the near future an increasing number of LHs will be performed due to the wider implementation of this surgical technique, the absolute number of conversions is likely to rise over time. To stay ahead of these developments

and to answer the increasing demands of Health Inspectorates, professionals and patients, it is essential to acquire better insight into conversion rate as a means of evaluation in LH.

The aim of this study was threefold. Firstly, based on prospectively obtained data, we estimated the influence of patient, procedure and performer characteristics on conversion in LH. Secondly, while no systematic data on conversion rates is available at present, we performed a systematic search of the literature to provide a basis for evaluation. Thirdly, supported by these two results, we hypothesize the extent to which conversion rate can act as a means of evaluation in laparoscopic hysterectomy.

Materials and Methods

In order to provide a current estimate of the conversion rate in LH, we searched the literature on PubMed using the following terms: 'hysterectomy', 'laparoscopy' and 'conversion'. We limited the results to original observational studies and randomized controlled trials (RCTs) published after the year 2000, written in English and with an available abstract. We excluded all publications concerning robotic (assisted) hysterectomy, single incision and/or radical hysterectomy for oncological indications. We also excluded studies that did not report the actual percentage of procedures converted to laparotomy. In cases where the indication for conversion was clearly mentioned, we calculated the proportion of strategic conversions.

To estimate independent risk factors for conversion in LH, we analyzed the data obtained from the LapTop study (2008-2010): a prospective nationwide cohort in which 79 gynecologists in the Netherlands who performed LHs were enrolled and registered for a period of one year every LH that he/she performed as a primary surgeon. Out off all gynecologists performing LH in the Netherlands, this reflects 75% (and 68% of the hospitals (N=42)). Potential risk factors for conversion were identified and consisted of patient, procedure, and performer characteristics. Besides the age of the patient and the indication for LH, these characteristics included body mass index (BMI, kg/m^2), prior abdominal surgery (including Caesarean sections), and ASA classification. Procedure characteristics included the type of LH performed [i.e. laparoscopic assisted vaginal hysterectomy (LAVH), supracervical laparoscopic hysterectomy (SLH) or total laparoscopic hysterectomy (TLH)], the accompanying salpingo-oophorectomy and uterus weight (in grams, weighed in the operating room). Performer characteristics included the actual number of LHs performed, including the procedure to be registered. To be sure that all LHs performed were submitted, we double-checked 10% of the cases with the actual operating room statistics of each clinic. Parts of the collected data with regard to patient and surgeon factors as predictors for blood loss, operative time and adverse events have been published elsewhere.[14]

Adverse events were registered for type, severity (i.e. requiring re-intervention or not) and moment of onset, according to the definitions and regulations as determined by the Guideline Adverse Events of the Dutch Society of Obstetricians and Gynecologists.15 Conversion to laparotomy was defined as an abdominal incision made after the laparoscopic start up. Strategic conversions (e.g. due to inadequate visibility, adhesions or additional pathology) were distinguished from forced conversions to laparotomy due to an adverse event (reactive conversion). Additional information on the indication for conversion was to be reported in the comment section.

The procedure, patient and performer characteristics of this cohort were analyzed using SPSS 17.0 statistical software (Chicago, IL, USA) and p-values <.05 were considered to be statistically significant. The normality distribution of continuous and ordinal variables was tested using the Kolmogorov-Smirnov test. To describe non-normally distributed data the median and interquartile range (25^{th} and 75^{th} percentile, IQR) was used. For the clinical relevance of the outcomes, we stratified a number of continuous variables: BMI (<25, 25-35 and >35 kg/m^2), age (<45, 45-65, >65 years) and uterus weight (<200, 200-500, >500 grams). As a reference category for categorical variables, we chose the most relevant category, preferably with the highest number of cases. We used a mixed effects logistic regression model to calculate the 'adjusted' log odds ratio (OR) and the 95%-confidence intervals (95% CI) of each risk factor for conversion using R-2 10.0 statistical software (Vienna, Austria) with the lme4-package.[16] In the case of a categorical variable, the OR was relative to the reference category. The variables included in the model either had to show a significant association in the univariable analysis or otherwise had to be marked as clinically important by the researchers.

The influence of surgical experience (number of LHs performed) was estimated in two ways. Firstly, we estimated whether the risk of conversion is influenced by surgical experience, on a continuous scale per 10 consecutively performed procedures. Secondly, we estimated whether a dichotomous cut-off of >30 procedures influences the risk of conversion, since this value is generally accepted as the individual learning curve.[17,18]

We had to take into account the fact that we observed multiple procedures for each surgeon.[19] Two procedures performed by the same surgeon tend to be "more similar" than two procedures performed by two different surgeons. We modeled this type of similarity by using a mixed-effects logistic regression model, thus including random contributions specific to each surgeon. The standard deviation of these random contributions (estimated at log odds of the exponent) capture differences between surgeons that are not explained by the included covariates of the model. Because our model corrects for all measurable patient and surgeon factors, this standard deviation can be interpreted as an OR of factors that are not measurable as a number with a unit, such as the skills of the surgeon and the functionality of the complete operating team. Because, in the end, the surgeon is responsible for the surgical procedure as a whole, we referred to this variation that is not explained by directly measurable factors as the 'Surgical Skills Factor' (SSF). Using this approach, the calculated SSF can be used as an OR, describing the a priori difference in the risk of conversion between two randomly selected surgeons.

Results

From the literature search, we found a conversion rate in LH of 0-19% (Table 1).[20-52] We found 33 relevant studies, describing a total of 7827 procedures, of which 264 were converted to laparotomy (3.5%). We calculated that 73% of conversions could be regarded as strategic, in those studies that provided information on the reason for conversion.

A total of 1534 LHs were performed during the study period (2008-2010). The mean experience (number of LHs performed) per gynecologist at the start of the study was 51 procedures (median 28, range 0-250). During the study period of 12 months, the mean number of performed LHs was 14.9 per year (SD 10.7, range 1–50).

A total of 70 LHs (4.6%, 95% CI 4.3 – 4.9) were converted, of which 22 (31.4%, 95% CI 22.9 – 40.0) were identified as a reactive conversion and 48 (68.6%, 95% CI 60.0 – 77.1) as a strategic conversion (Table 2). The main reasons for a reactive conversion were: uncontrollable bleeding (63.6%), internal organ lesions (13.6%) and technical failure of equipment (13.6%). Strategic conversions were mainly due to visibility or mobility problems as a result of altered anatomy (e.g. adhesions, myomata) (70.8%), a too large uterus to be removed in one piece in case of malignancy (and therefore contra-indicated for morcellation) (14.6%) and anesthesiological problems due to morbid obesity (BMI>40 kg/m^2)(10.4%).

In the course of the one-year study period, 42 gynecologists reported no conversions, while 46.8% of the performers had to convert to laparotomy at least once; their individual conversion rate ranged from 1.3% to 33.3%. Experience of more than 30 LHs did not correlate with the risk of conversion (p=.734). Moreover, also the distribution between strategic and reactive conversions was not correlated with experience of more than 30 LHs (p=.168).

Overall patient and procedure characteristics are shown in Table 3. The independent risk factors for conversion were BMI (p=.002), age (p=.023), uterus weight (p<.001) and type of LH (p=.004) (Table 4). Relative to the reference category of these risk factors, significant categories were BMI >35 kg/m^2 (OR 6.53, p<.001), age >65 years (OR 6.97, p=.007), uterus weight between 200-500 gram (OR 4.05, p<.001) and uterus weight >500 grams (OR 30.90, p<.001). Compared to TLH, performing SLH significantly decreased the risk of conversion (OR .32, p=.02). History of prior abdominal surgery, ASA classification, accompanying salpingo-oophorectomy and indication for LH were not associated with conversion. Furthermore, surgical experience – both measured per 10 procedures on a continuous scale (OR 0.95, p=.090) and with a cut-off of >30 procedures (OR 0.60, p=.253 (the latter not shown in Table 4)) – was also not significantly associated with conversion. Although our model corrected for all these (measurable) covariates, it repeatedly calculated an influence of the 'variation not explained by the covariates' (the standard deviation of the random contributions) on the risk of conversion. Some immeasurable 'environmental' factors, consisting of factors related to the surgeon, the OR team or organizational factors, were accountable for this effect and were therefore referred to as the 'Surgical Skills Factor' (SSF). The standard deviation

Table 1 Reported conversion rates in laparoscopic hysterectomy

Author (year)	Type of LH	Design	n	Converted	Conversion rate	Strategic conversion
Brummer *et al.*(2009)	Mixed	Prospective cohort	1686	87	5,2%	76%
Candiani *et al.*(2009)	TLH	Prospective cohort	30	0	0,0%	-
Chang *et al.*(2005)	LAVH	Prospective cohort	225	2	0,9%	0%
Chen *et al.*(2008)	LAVH	Prospective cohort	147	1	0,7%	0%
Daraï *et al.*(2001)	LAVH	Randomized Controlled Trial	40	3	7,5%	67%
David-Montfiore *et al.*(2007)	Mixed	Prospective cohort	121	23	19,0%	65%
Donnez *et al.*(2010)	Mixed	Prospective cohort	400	0	0,0%	-
Drahonovsky *et al.*(2010)	Mixed	Randomized Controlled Trial	125	3	2,4%	unknown
Erian *et el.*(2005)	SLH	Prospective cohort	100	0	0,0%	-
Garry *et al.*(2004)	Mixed	Randomized Controlled Trial	920	32	3,5%	72%
Ghezzi *et al.*(2010)	TLH	Randomized Controlled Trial	41	0	0,0%	-
Ghomi *et al.*(2007)	SLH	Prospective cohort	60	1	1,7%	0%
Holub *et al.*(2001)	LAVH	Prospective cohort	271	3	1,1%	33%
Johnston *et al.*(2007)	Mixed	Prospective cohort	364	4	1,1%	75%
Karaman *et al.*(2007)	Mixed	Prospective cohort	1120	26	2,3%	92%
Kluivers *et al.*(2007)	Mixed	Randomized Controlled Trial	27	2	7,4%	100%
Kreiker *et al.*(2004)	LAVH	Prospective cohort	160	5	3,1%	100%
Leung *et al.*(2007)	Mixed	Prospective cohort	143	1	0,7%	100%
Lieng *et al.*(2005)	SLH	Prospective cohort	43	1	2,3%	0%
Long *et al.*(2002)	Mixed	Prospective cohort	104	3	2,9%	unknown
Mourits *et al.*(2010)	TLH	Randomized Controlled Trial	185	20	10,8%	60%
Mueller *et al.*(2011)	TLH	Prospective cohort	567	1	0,2%	100%
Muzii *et al.*(2007)	LAVH	Randomized Controlled Trial	40	2	5,0%	0%
Obermair *et al.*(2012)	TLH	Randomized Controlled Trial	404	24	5,9%	unknown
Ottosen *et al.*(2000)	LAVH	Prospective cohort	40	4	10,0%	75%
Pan *et al.*(2008)	TLH	Prospective cohort	132	9	6,8%	100%
Persson *et al.*(2006)	LAVH	Randomized Controlled Trial	63	3	4,8%	33%
Schütz *et al.*(2002)	LAVH	Prospective cohort	28	0	0,0%	-
Seracchioli *et al.*(2002)	TLH	Randomized Controlled Trial	60	1	1,7%	0%
Sesti *et al.*(2008)	LAVH	Randomized Controlled Trial	50	0	0,0%	-
Shahid *et al.*(2009)	SLH	Prospective cohort	29	0	0,0%	-
Soriano *et al.*(2001)	LAVH	Randomized Controlled Trial	40	3	7,5%	100%
Wang *et al.*(2005)	LAVH	Prospective cohort	62	0	0,0%	-
Total			7827	264	3,5%	73%[a]

[a] weighted average

Table 2 Main reasons for strategic and reactive conversion (*n* = 1.534)

	***n* (%, 95% CI)**
Strategic conversions	48 (68.6, 60.0 to 77.1)
Visibility/mobility problems	34 (70.8)
Risk for spill	7 (14.6)
Anesthesiologic problems	5 (10.4)
Reactive conversions	22 (31.4, 22.9 to 40.0)
Uncontrollable bleeding	14 (63.6)
Internal organ lesion	3 (13.6)
Technical failure of equipment	3 (13.6)
Total number of conversions	70 (4.6, 4.3 to 4.9)

Table 3 An overview of the main patient and procedure characteristics and adverse events of the total cohort (*n* = 1.534)

I Patient characteristics	**median**	**IQR[a]**			**min**	**-**	**max**
Age (years)	46.4	41.7	-	51.1	13.0	-	89.3
BMI (kg/m^2)	27.5	22.5	-	28.1	17.5	-	56
Parity	2	0	-	2	0	-	5
Uterus weight (grams)	150	97	-	285	14	-	1600
Indication to LH	*n* (%)						
Dysfunctional uterine bloodloss	762 (49.7)						
Uterus myomatosus	420 (27.4)						
(Pre)malignancy endometrium or cervix	236 (15.4)						
Endometriosis	34 (2.2)						
Others (profylactic, gender change)	80 (5.2)						
Previous abdominal surgeries							
No	918 (59.9)						
1	397 (25.9)						
2	143 (9.3)						
> 2	50 (3.3)						

Table 3 Continued from previous page

II Procedure characteristics	**median**	**IQR[a]**			**min**	-	**max**
Operative time (min)	110	90	-	135	32	-	344
Converted cases (*n* = 70)	120	100	-	175	34	-	330
Blood loss (mL)	100	50	-	200	0	-	2600
Converted cases (*n* = 70)	500	300	-	950	10	-	2500
Type of LH	*n* (%)						
TLH	957 (62.4)						
LAVH	185 (12.1)						
SLH	391 (25.5)						
BSO performed	362 (23.6)						
III Adverse events	***n* (%)**						
Procedures with ≥ 1 adverse event(s)	116 (7.6)						
Infection	12 (0.8)						
Lesion internal organ	29 (1.9)						
Lesion vessel	8 (0.5)						
Wound dehiscence	15 (1.0)						
Blood loss > 1000mL	43 (2.8)						
Venous thromboembolism	2 (0.1)						
Others	21 (1.4)						
No (re)intervention needed	105 (6.8)						
Intervention needed	25 (1.6)						
Moment of adverse event							
During procedure	67 (4.4)						
On hospital ward	36 (2.3)						
After hospital discharge	27 (1.8)						

All continuous and ordinal variables shown were not normally distributed (Kolmogorov-Smirnov test)

[a] Interquartile range (25^{th} and 75^{th} percentile)

Table 4 Risk factors and adjusted odds ratios[a] for conversion to laparotomy in LH

	n	Conversions (% of total)	aOR	95% CI	*P* value
Age (years)					.023
<45	528	16 (3.0)	1.0	(reference)	
45-65	689	40 (5.8)	1.39	.68 - 2.83	.366
>65	75	9 (12.0)	6.97	1.72 - 28.27	.007
BMI (kg/m²)					.002
<25	531	13 (2.4)	1.0	(reference)	
25-35	653	36 (5.5)	1.90	.90 - 4.00	.093
>35	108	16 (14.8)	6.53	2.27 - 18.78	<.001
Uterusweight (grams)					<.001
<200	760	19 (2.5)	1.0	(reference)	
200-500	408	24 (5.9)	4.05	1.87 - 8.79	<.001
>500	124	22 (17.7)	30.90	11.72 - 81.48	<.001
History of prior abdominal surgery					.544
No	773	38 (4.9)	1.0	(reference)	
≥1 procedures	519	27 (5.2)	1.20	.65 - 2.22	
ASA classification					.118
ASA I	903	35 (3.9)	1.0	(reference)	
ASA II	357	24 (6.7)	1.36	.68 - 2.72	
ASA III & IV	32	6 (18.8)	5.39	1.12 - 25.84	
Type of LH					.004
TLH	787	42 (5.3)	1.0	(reference)	
SLH	343	11 (3.2)	.32	.12 - .83	.019
LAVH	162	12 (7.4)	2.07	.80 - 5.36	.132
BSO performed					.069
No	1014	52 (5.1)	1.0	(reference)	
Yes	278	13 (4.7)	.39	.13 - 1.16	
Indication					.785
Dysfunctional uterine bleeding	656	28 (4.3)	1.0	(reference)	
Uterus myomatosus	361	23 (6.4)	.83	.39 - 1.75	
(Pre)malignancy (endometrium or cervix)	176	13 (7.4)	1.61	.51 - 5.06	
Endometriosis	31	1 (3.2)	1.01	.09 - 10.83	
Other (e.g. gender change, prophylaxis)	68	0	N/A[b]		

Table 4 Continued from previous page

	n	Conversions (% of total)	aOR	95% CI	*P* value
Surgical experience (continuous)[c]			.95	.89 - 1.01	.09
Surgical Skills Factor			2.79[d]		.001

The mixed effects logistic regression model was based on 1292 cases, since 242 cases were excluded due to at least one missing parameter.

[a] Relative to the reference category in case of a categorical variable

[b] Could not be calculated, since no conversions occurred. This did not affect the aORs of all other covariates

[c] per 10 consecutive procedures performed

[d] average odds ratio

of these random contributions was, independent of the included covariates, estimated at a log odds of 1.03 (p=.001) for the risk of conversion. This means that between two randomly selected surgeons, on average, an intrinsic OR of 2.79 (Exp(1.03)) on the risk of conversion was present. The multivariable analysis was based on 1292 cases because 242 cases were excluded due to at least one missing parameter (15.7%). These excluded cases contained 5 converted procedures.

Discussion

Strategic considerations are in the majority of cases (69%) the reason for converting laparoscopic hysterectomy to the conventional abdominal approach. Visibility and/or mobility problems are the main reason for this type of conversion, while uncontrollable bleeding is the main adverse event leading to a reactive conversion. As reported in other studies, BMI and uterus weight are confirmed to be independent risk factors for conversion.[53-55] However, a new effect shown in our study is that this risk increases with a BMI >35 kg/m^2 (approximately 6.5-fold), an age >65 years (approximately 7-fold), a uterus weight between 200-500 grams (approximately 4-fold) and a uterus weight >500 grams (approximately 30-fold). On the other hand, performing SLH, compared to TLH, decreases the risk of conversion (approximately 3-fold). Surgical experience did not directly correlate with the conversion rate. However, we identified the presence of an intrinsic factor influencing the risk of conversion, which we referred to as the Surgical Skills Factor (SSF).

The majority of the LHs (>95%) are completed laparoscopically as planned. To facilitate an increase in this rate and further improvement of the quality assurance in LH, in our opinion, conversion rate can be considered as a means of evaluation. In general, conversion should be viewed as a phenomenon inherent to laparoscopic surgery, being a calculated risk and a sign of good surgical judgment.[56] Nevertheless, from a quality control point of view, just as registration

of adverse events is mandatory in every clinic, this registration should also include the numbers of conversions and its indication. A subdivision into strategic and reactive conversions will be helpful in daily practice, since a reactive conversion is associated with a higher risk of post-operative adverse events and a prolonged hospital stay.[9,10] Additionally, while strategic conversions potentially are the result of suboptimal pre-operative patient evaluation, an insufficiently trained surgeon and operating team might cause either a strategic or a reactive conversion. In the end, such a registration can be used as an additional means of evaluation of LH, in which pre-eminently the rate of strategic conversions can provide information about patient selection, indication and the surgical skills of the gynecologist and the operating team.

Furthermore, each clinic should evaluate the ratio of vaginal hysterectomies (VH), abdominal hysterectomies (AH) and LHs performed over the years. Ideally, on hypothetical grounds the rate of VH has to remain steady, while an optimum rate of LH should be reached, with subsequent low numbers of primary AHs.[25,57-63] In order to accomplish this we have to assure and further improve the quality of the surgical procedure (in this case LH), by using additional means of evaluation of the procedure, such as the conversion rate and its subdivision. Imaginably, surgeons could fear such a measurement and therefore might refrain from the laparoscopic approach in some cases. However, this will deprive patients from the advantages of a minimally invasive approach, consequently obscuring the true indication for the abdominal approach. We would like to stress, that the need to perform a conversion will always remain. Moreover, a proper registration can be both a means of evaluation as well as a helpful tool for each surgeon. As a consequence, opportunities are provided that eventually might be able to reduce both the conversion rate in LH and the rate of abdominal hysterectomy as a whole.

With regard to the risk factors for conversion, a number of studies report a correlation between surgical experience and conversion rate.[4,5,53,64] However, in our study, we found no significant increase in the risk of (strategic or reactive) conversions within the group of less-experienced gynecologists (<30 procedures). This is most probably the result of various teaching or mentorship programs, which gynecologists who are novices with respect to LH are now obliged to attend, thereby protecting patients from an increased risk of adverse outcomes and conversions.[65]

On the other hand, we repeatedly found that the risk of conversion is substantially influenced (OR 2.79, p=.001) by the presence of an intrinsic factor that - independently of experience - represents surgical skills and the functionality of the operating team. Although this assessment might be somewhat precarious, others also stated that, as a predictor for surgical outcome, surgical skills seem to play a more important role than surgical experience alone and therefore it should not be ignored.[66] Similarly, it has been argued that measuring structures and processes of care, which incorporate individual skills, may be a better means of evaluation, rather than the conventional focus on outcome measurements.[67,68] If we compare testing proficiency in surgery to driving a car, we can state the following metaphor. Not only the fact that the driver has acquired its driver's license (i.e. a completed learning curve) and how many times he or she has driven a car before determine the outcome of the drive, also the skills of the driver (or the instructor) and the functionality of the car influence the outcome of each ride. Thus, in our opinion, although easier to assess, surgical experience should not solely be used as a safeguard

to prevent conversion. On the contrary, we should be aware of the presence of such an intrinsic SSF influencing the risk of conversion.

Although studies have been published on odds ratios that were adjusted for the influence of BMI on conversion rate, our study provides stratified groups rather than an odds ratio per point increase, which makes it clinically more relevant.[53,55] This stratification is, in our opinion, more useful in daily practice and will allow for better informed consent.

Some claim that conversion rate is more related to the shape of the uterus rather than its weight (e.g. myomata).[55] Although we think that the shape certainly may influence the outcome, our analysis showed a very strong independent association between conversion and uterus weight. With respect to the influence of age on conversion, some studies state no correlation.[53,55,69] However, a recently published nationwide study on this matter showed an increasing conversion rate in elder patients.[70] Furthermore, the significant influence of age >65 years can be explained by a relatively high conversion rate associated with (pre)malignant indications within this subgroup (12.3%, not shown). Although apparently this combination has an increased risk of (strategic) conversion, it is important to note that still the vast majority of this subgroup can benefit from the advantages of the laparoscopic approach. Moreover, since (pre)malignant indication shows a trend towards a higher risk of conversion, this partly explains why performing SLH seems to be associated with a significantly lower risk of conversion. Furthermore, on theoretical grounds, the lack of colpotomy in SLH, often regarded a difficult surgical step, facilitates lower conversion rates. However, SLH should not be performed at the expense of a proper indication.

From our findings we suggest when counseling the laparoscopic approach one should be aware of the aforementioned patient risk factors and evaluate one's personal (i.e. team) tendency to convert. When in doubt, one should ask for expert help or refer this patient. However, if past performances are reassuring, also challenging patients should be offered the laparoscopic approach.

The overall conversion rate of 4.6% in LH in our cohort is representative for the Netherlands: 75% of the Dutch gynecologists who perform LH fully participated in the study, and the patient and procedure characteristics were similar to the data we found in the literature [20,29]. However, this figure is somewhat higher than the 3.5% conversion rate we identified in our literature review. This is probably due to the fact that our cohort represents a country as a whole, reflecting daily practice instead of the specific experience of a single surgeon or center. A drawback of this study is the influence of a possible selection bias because all gynecologists worked by their individual criteria whether to perform the hysterectomy laparoscopically instead of abdominally or vaginally. However, this reflects the actual clinical situation in which all gynecologists try to use proper indication criteria to the extent of his/her surgical experience and skills. Furthermore, as shown in Table 3, patient characteristics in our cohort are comparable to other large studies.[20,29] In addition, in collecting our data, we had to rely on each individual gynecologist who submitted each performed procedure. We did not identify any missing procedures during the double-check. In our study design, the registration of a diagnostic laparoscopy followed by an abdominal hysterectomy might potentially have led to underreporting of the number of conversions. However, we cannot think of any indication justifying this option as an optimal treatment and,

based on our definition for conversion (stated in the study protocol), even such a procedure should have been registered as a conversion.

Conclusion

In conclusion, since this study presents data collected from many centers, rather than a single (experienced) centre, the results could be interpreted as applying nationwide. We therefore suggest that, supported by our literature review, a conversion rate of <5% can act as a reference for future comparison. If a hospital exceeds this percentage, they should conduct an audit of their converted LHs. The questions to be asked would include: did intra-operative adverse events occur, were indications properly made, were the skills of the surgeon and the functionality of the operating team adequate? In addition, the subdivision between strategic and reactive conversions allows better identification of conversions that could be avoided. Furthermore, the balance between strategic (70%) and reactive conversion (30%) provides information on the implementation of the above-mentioned risk factors in the indication for LH. Therefore, conversion rate in general and the rate of strategic conversions in particular represent a tool for the evaluation of LH. In this way, additional insight in the indications for conversion can be acquired, allowing further improvement of the outcomes in LH and preventing future patients from unnecessary conversions.

Acknowledgements

The authors would like to thank all gynecologists in the Netherlands who participated in the LapTop study and provided us the necessary data.

References

1. Reich H, Decaprio J, McGlynn F. Laparoscopic hysterectomy. *J Gynaecol Surg.* 1989; 5:213-6.
2. Nieboer TE, Johnson N, Lethaby A et al. Surgical approach to hysterectomy for benign gynaecological disease. *Cochrane Database Syst Rev.* 2009;CD003677.
3. Atkinson SW. Results of eVALuate study of hysterectomy techniques: conversion to open surgery should not be regarded as major complication. *BMJ.* 2004; 328:642.
4. Visco AG, Barber MD, Myers ER. Early physician experience with laparoscopically assisted vaginal hysterectomy and rates of surgical complications and conversion to laparotomy. *Am J Obstet Gynecol.* 2002; 187:1008-12.
5. Chapron C, Querleu D, Bruhat MA et al. Surgical complications of diagnostic and operative gynaecological laparoscopy: a series of 29,966 cases. *Hum Reprod.* 1998; 13:867-72.
6. Hunter RW, McCartney AJ. Can laparoscopic assisted hysterectomy safely replace abdominal hysterectomy? *Br J Obstet Gynaecol.* 1993; 100:932-4.
7. Chew MH, Ng KH, Fook-Chong MC et al. Redefining conversion in laparoscopic colectomy and its influence on outcomes: analysis of 418 cases from a single institution. *World J Surg.* 2011; 35:178-85.
8. Gervaz P, Pikarsky A, Utech M et al. Converted laparoscopic colorectal surgery. *Surg Endosc.* 2001; 15:827-32.
9. Yang C, Wexner SD, Safar B et al. Conversion in laparoscopic surgery: does intraoperative complication influence outcome? *Surg Endosc.* 2009; 23:2454-8.
10. Dindo D, Schafer M, Muller MK et al. Laparoscopy for small bowel obstruction: the reason for conversion matters. *Surg Endosc.* 2010;792-7.
11. Landheer ML, Therasse P, van de Velde CJ. The importance of quality assurance in surgical oncology. *Eur J Surg Oncol.* 2002; 28:571-602.
12. Peeters KC, van de Velde CJ. Surgical quality assurance in breast, gastric and rectal cancer. *J Surg Oncol.* 2003; 84:107-12.
13. Verleye L, Vergote I, Reed N et al. Quality assurance for radical hysterectomy for cervical cancer: the view of the European Organization for Research and Treatment of Cancer--Gynecological Cancer Group (EORTC-GCG). *Ann Oncol.* 2009; 20:1631-8.
14. Twijnstra AR, Blikkendaal MD, van Zwet EW et al. Predictors of Successful Surgical Outcome in Laparoscopic Hysterectomy. *Obstet Gynecol.* 2012; 119:700-8.
15. Twijnstra AR, Zeeman GG, Jansen FW. A novel approach to registration of adverse outcomes in obstetrics and gynaecology: a feasibility study. *Qual Saf Health Care.* 2010; 19:132-7.
16. Bates D, Maechler M, Bolker B. lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-35. 2011.
17. Altgassen C, Michels W, Schneider A. Learning laparoscopic-assisted hysterectomy. *Obstet Gynecol.* 2004; 104:308-13.
18. Makinen J, Johansson J, Tomas C et al. Morbidity of 10 110 hysterectomies by type of approach. *Hum Reprod.* 2001; 16:1473-8.
19. Urbach DR, Austin PC. Conventional models overestimate the statistical significance of volume-outcome associations, compared with multilevel models. *J Clin Epidemiol.* 2005; 58:391-400.
20. Brummer TH, Jalkanen J, Fraser J et al. FINHYST 2006--national prospective 1-year survey of 5,279 hysterectomies. *Hum Reprod.* 2009; 24:2515-22.
21. Candiani M, Izzo S, Bulfoni A et al. Laparoscopic vs vaginal hysterectomy for benign pathology. *Am J Obstet Gynecol.* 2009; 200:368-7.
22. Chang WC, Torng PL, Huang SC et al. Laparoscopic-assisted vaginal hysterectomy with uterine artery ligation through retrograde umbilical ligament tracking. *J Minim Invasive Gynecol.* 2005; 12:336-42.
23. Chen SY, Chang DY, Sheu BC et al. Laparoscopic-assisted vaginal hysterectomy with in situ morcellation for large uteri. *J Minim Invasive Gynecol.* 2008; 15:559-65.
24. Darai E, Soriano D, Kimata P et al. Vaginal hysterectomy for enlarged uteri, with or without laparoscopic assistance: randomized study. *Obstet Gynecol.* 2001; 97:712-6.
25. David-Montefiore E, Rouzier R, Chapron C et al. Surgical routes and complications of hysterectomy for benign disorders: a prospective observational study in French university hospitals. *Hum Reprod.* 2007; 22:260-5.
26. Donnez O, Donnez J. A series of 400 laparoscopic hysterectomies for benign disease: a single centre, single surgeon prospective study of complications confirming previous retrospective study. *BJOG.* 2010; 117:752-5.
27. Drahonovsky J, Haakova L, Otcenasek M et al. A prospective randomized comparison of vaginal hysterectomy, laparoscopically assisted vaginal hysterectomy, and total laparoscopic hysterectomy in women with benign uterine disease. *Eur J Obstet Gynecol Reprod Biol.* 2010; 148:172-6.
28. Erian J, El-Toukhy T, Chandakas S et al. One hundred cases of laparoscopic subtotal hysterectomy using the PK and Lap Loop systems. *J Minim Invasive Gynecol.* 2005; 12:365-9.

29. Garry R, Fountain J, Brown J et al. EVALUATE hysterectomy trial: a multicentre randomised trial comparing abdominal, vaginal and laparoscopic methods of hysterectomy. *Health Technol Assess*. 2004; 8:1-154.
30. Ghezzi F, Uccella S, Cromi A et al. Postoperative pain after laparoscopic and vaginal hysterectomy for benign gynecologic disease: a randomized trial. *Am J Obstet Gynecol*. 2010; 203:118.
31. Ghomi A, Littman P, Prasad A et al. Assessing the learning curve for laparoscopic supracervical hysterectomy. *JSLS*. 2007; 11:190-4.
32. Holub Z, Jabor A, Kliment L et al. Laparoscopic hysterectomy in obese women: a clinical prospective study. *Eur J Obstet Gynecol Reprod Biol*. 2001; 98:77-82.
33. Johnston K, Rosen D, Cario G et al. Major complications arising from 1265 operative laparoscopic cases: a prospective review from a single center. *J Minim Invasive Gynecol*. 2007; 14:339-44.
34. Karaman Y, Bingol B, Gunenc Z. Prevention of complications in laparoscopic hysterectomy: experience with 1120 cases performed by a single surgeon. *J Minim Invasive Gynecol*. 2007; 14:78-84.
35. Kluivers KB, Hendriks JC, Mol BW et al. Quality of life and surgical outcome after total laparoscopic hysterectomy versus total abdominal hysterectomy for benign disease: a randomized, controlled trial. *J Minim Invasive Gynecol*. 2007; 14:145-52.
36. Kreiker GL, Bertoldi A, Larcher JS et al. Prospective evaluation of the learning curve of laparoscopic-assisted vaginal hysterectomy in a university hospital. *J Am Assoc Gynecol Laparosc*. 2004; 11:229-35.
37. Leung SW, Chan CS, Lo SF et al. Comparison of the different types of "laparoscopic total hysterectomy". *J Minim Invasive Gynecol*. 2007; 14:91-6.
38. Lieng M, Istre O, Langebrekke A et al. Outpatient laparoscopic supracervical hysterectomy with assistance of the lap loop. *J Minim Invasive Gynecol*. 2005; 12:290-4.
39. Long CY, Fang JH, Chen WC et al. Comparison of total laparoscopic hysterectomy and laparoscopically assisted vaginal hysterectomy. *Gynecol Obstet Invest*. 2002; 53:214-9.
40. Mourits MJ, Bijen CB, Arts HJ et al. Safety of laparoscopy versus laparotomy in early-stage endometrial cancer: a randomised trial. *Lancet Oncol*. 2010; 11:763-71.
41. Mueller A, Boosz A, Koch M et al. The Hohl instrument for optimizing total laparoscopic hysterectomy: results of more than 500 procedures in a university training center. *Arch Gynecol Obstet*. 2011.
42. Muzii L, Basile S, Zupi E et al. Laparoscopic-assisted vaginal hysterectomy versus minilaparotomy hysterectomy: a prospective, randomized, multicenter study. *J Minim Invasive Gynecol*. 2007; 14:610-5.
43. Obermair A, Janda M, Baker J et al. Improved surgical safety after laparoscopic compared to open surgery for apparent early stage endometrial cancer: Results from a randomised controlled trial. *Eur J Cancer*. 2012; 48:1147-53.
44. Ottosen C, Lingman G, Ottosen L. Three methods for hysterectomy: a randomised, prospective study of short term outcome. *BJOG*. 2000; 107:1380-5.
45. Pan HS, Ko ML, Huang LW et al. Total laparoscopic hysterectomy (TLH) versus coagulation of uterine arteries (CUA) at their origin plus total laparoscopic hysterectomy (TLH) for the management of myoma and adenomyosis. *Minim Invasive Ther Allied Technol*. 2008; 17:318-22.
46. Persson P, Wijma K, Hammar M et al. Psychological wellbeing after laparoscopic and abdominal hysterectomy--a randomised controlled multicentre study. *BJOG*. 2006; 113:1023-30.
47. Schutz K, Possover M, Merker A et al. Prospective randomized comparison of laparoscopic-assisted vaginal hysterectomy (LAVH) with abdominal hysterectomy (AH) for the treatment of the uterus weighing >200 g. *Surg Endosc*. 2002; 16:121-5.
48. Seracchioli R, Venturoli S, Vianello F et al. Total laparoscopic hysterectomy compared with abdominal hysterectomy in the presence of a large uterus. *J Am Assoc Gynecol Laparosc*. 2002; 9:333-8.
49. Sesti F, Calonzi F, Ruggeri V et al. A comparison of vaginal, laparoscopic-assisted vaginal, and minilaparotomy hysterectomies for enlarged myomatous uteri. *Int J Gynaecol Obstet*. 2008; 103:227-31.
50. Shahid A, Sankaran S, Odejinmi F. Laparoscopic subtotal hysterectomy for large uteri using modified five port technique. *Arch Gynecol Obstet*. 2011; 283:79-81.
51. Soriano D, Goldstein A, Lecuru F et al. Recovery from vaginal hysterectomy compared with laparoscopy-assisted vaginal hysterectomy: a prospective, randomized, multicenter study. *Acta Obstet Gynecol Scand*. 2001; 80:337-41.
52. Wang CJ, Yuen LT, Yen CF et al. Comparison of the efficacy of the pulsed bipolar system and conventional bipolar electrosurgery in laparoscopically assisted vaginal hysterectomy. *J Laparoendosc Adv Surg Tech A*. 2005; 15:361-4.
53. Sokol AI, Chuang K, Milad MP. Risk factors for conversion to laparotomy during gynecologic laparoscopy. *J Am Assoc Gynecol Laparosc*. 2003; 10:469-73.
54. Kondo W, Bourdel N, Marengo F et al. Surgical outcomes of laparoscopic hysterectomy for enlarged uteri. *J Minim Invasive Gynecol*. 2011; 18:310-3.

55. Leonard F, Chopin N, Borghese B et al. Total laparoscopic hysterectomy: preoperative risk factors for conversion to laparotomy. *J Minim Invasive Gynecol.* 2005; 12:312-7.
56. Lengyel BI, Azagury D, Varban O et al. Laparoscopic cholecystectomy after a quarter century: why do we still convert? *Surg Endosc.* 2012; 26:508-13.
57. Brummer TH, Seppala TT, Harkki PS. National learning curve for laparoscopic hysterectomy and trends in hysterectomy in Finland 2000-2005. *Hum Reprod.* 2008; 23:840-5.
58. Twijnstra AR, Kolkman W, Trimbos-Kemper GC et al. Implementation of advanced laparoscopic surgery in gynecology: national overview of trends. *J Minim Invasive Gynecol.* 2010; 17:487-92.
59. van der Wat J. When will laparoscopy totally replace laparotomy? *J Minim Invasive Gynecol.* 2012; 19:236-7.
60. Kluivers KB, Opmeer BC, Geomini PM et al. Women's preference for laparoscopic or abdominal hysterectomy. *Gynecol Surg.* 2009; 6:223-8.
61. Nieboer TE, Hendriks JC, Bongers MY et al. Quality of life after laparoscopic and abdominal hysterectomy: a randomized controlled trial. *Obstet Gynecol.* 2012; 119:85-91.
62. Kluivers KB, Johnson NP, Chien P et al. Comparison of laparoscopic and abdominal hysterectomy in terms of quality of life: a systematic review. *Eur J Obstet Gynecol Reprod Biol.* 2008; 136:3-8.
63. Bijen CB, Vermeulen KM, Mourits MJ et al. Costs and effects of abdominal versus laparoscopic hysterectomy: systematic review of controlled trials. *PLoS One.* 2009; 4:e7340.
64. Heinberg EM, Crawford BL, III, Weitzen SH et al. Total laparoscopic hysterectomy in obese versus nonobese patients. *Obstet Gynecol.* 2004; 103:674-80.
65. Twijnstra AR, Blikkendaal MD, Kolkman W et al. Implementation of Laparoscopic Hysterectomy: Maintenance of Skills after a Mentorship Program. *Gynecol Obstet Invest.* 2010; 70:173-8.
66. Sarker SK, Kumar I, Delaney C. Assessing operative performance in advanced laparoscopic colorectal surgery. *World J Surg.* 2010; 34:1594-603.
67. Leake PA, Urbach DR. Measuring processes of care in general surgery: assessment of technical and nontechnical skills. *Surg Innov.* 2010; 17:332-9.
68. Fink AS, Itani KM, Campbell DC, Jr. Assessing the quality of surgical care. *Surg Clin North Am.* 2007; 87:837-52, vi.
69. Bijen CB, de Bock GH, Vermeulen KM et al. Laparoscopic hysterectomy is preferred over laparotomy in early endometrial cancer patients, however not cost effective in the very obese. *Eur J Cancer.* 2011.
70. Stang A, Merrill RM, Kuss O. Nationwide rates of conversion from laparoscopic or vaginal hysterectomy to open abdominal hysterectomy in Germany. *Eur J Epidemiol.* 2011.