

# Adhesion-related readmissions following gynaecological laparoscopy or laparotomy in Scotland: an epidemiological study of 24 046 patients

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**BACKGROUND:** Gynaecological laparotomies are associated with considerable adhesion-related burdens; however, few data are available concerning laparoscopic surgery. This study evaluated the epidemiology of adhesion-related readmissions following open and laparoscopic procedures. **METHODS:** Records from 24 046 patients undergoing gynaecological surgery in Scottish National Health Service hospitals during 1996 were assessed retrospectively. Cohorts comprised 15 197 patients undergoing laparoscopic surgery and 8849 patients undergoing laparotomies. Adhesion-related readmission episodes (directly and possibly related) were assessed over 4 years following initial surgery and were expressed as percentages of the number of initial procedures. **RESULTS:** Directly adhesion-related readmissions 1 year after initial laparoscopic surgery were: in the high-risk group (adhesiolysis and cyst drainage) 1.3%; medium-risk (therapeutic and diagnostic procedures not categorized as high- or low-risk) 1.5%; and low-risk (Fallopian tube sterilizations) 0.2%. Readmissions for laparotomy following surgery on the Fallopian tubes were 0.9%, ovaries 2.1%, uterus 0.6% and vagina 0%. Readmissions occurred at reduced rates in the second, third and fourth years after surgery. Exclusion of patients who underwent surgery within the previous 5 years resulted in reduced readmission rates following laparotomy and high-risk laparoscopy. **CONCLUSIONS:** With the exception of laparoscopic sterilizations, open and laparoscopic gynaecological surgery are associated with comparable risks of adhesion-related readmissions.

*Key words:* adhesions/epidemiology/gynaecology/laparoscopy/SCAR

## Introduction

Post-surgical adhesions are a widespread and largely unacknowledged problem that represent a considerable burden to patients in terms of re-operations (Ivarsson *et al.*, 1997), and perioperative and postoperative complications such as enterotomy (van der Krabben *et al.*, 2000), small bowel obstruction (Ellis, 1998), chronic pelvic pain (Howard, 1993; Duffy and diZerega, 1996) and infertility (Monk *et al.*, 1994; Liakakos *et al.*, 2001). The readmission of many patients to hospital for adhesion-related complications also places a considerable burden on surgeons and health-care providers in terms of bed space, health-care costs (Ivarsson *et al.*, 1997; Ray *et al.*, 1998; Beck *et al.*, 2000; Menzies *et al.*, 2001), extended theatre times (Beck *et al.*, 2000; Coleman *et al.*, 2000), more complex surgical procedures (Beck *et al.*, 2000; van der Krabben *et al.*, 2000) and added pressure on waiting lists.

Post-surgical adhesions form as a result of a range of insults (such as surgical trauma, infection, ischaemia, and exposure to intestinal contents and foreign materials) that

disrupt the peritoneum and cause inflammation (Diamond and Freeman, 2001). Adhesion development begins during surgery and proceeds rapidly. Re-epithelialization is achieved within 5–7 days and adhesion formation follows if damaged surfaces remain in apposition (Holmdahl *et al.*, 1997; diZerega and Campeau, 2001).

Corrective surgery is often required to resolve adhesion-related complications; however, additional surgery tends to encourage the development of additional (de-novo) adhesions and the reformation of lysed adhesions (Beck *et al.*, 2000). As many as 93% of patients undergoing laparotomies develop adhesions attributable to earlier surgery (Menzies and Ellis, 1990) and up to 85% of adhesions reform following adhesiolysis (Diamond and Freeman, 2001). Furthermore, reformed adhesions tend to be denser and more severe than de-novo adhesions (van der Krabben *et al.*, 2000).

With the increasing use of surgery to treat gynaecological conditions (particularly infertility), adhesions now represent a growing problem for gynaecologists (Lower *et al.*, 2000).

Intra-abdominal adhesions occur in 60–90% of women who have undergone major gynaecological procedures and account for 15–20% of cases of secondary infertility (Mishell and Davajan, 1991; Liakakos *et al.*, 2001). They are also associated with substantial morbidity, constituting one of the most common causes of pelvic pain in women (Mishell and Davajan, 1991; Howard, 1993; Duffy and diZerega, 1996; Diamond and Freeman, 2001). Furthermore, initial surgery in one region may result in adhesions in another, such that women undergoing gynaecological procedures may develop adhesive small bowel obstruction (Lower *et al.*, 2000).

The Surgical and Clinical Adhesions Research (SCAR) study was an epidemiological study that investigated the burden of post-surgical adhesions by analysing hospital readmissions in Scottish National Health Service (NHS) patients ( $n = 54\text{--}380$ ) within the 10 years following initial open abdominopelvic surgery during 1986. The study included an assessment of the impact of adhesions following initial open gynaecological surgery in a cohort of 8849 women (Ellis *et al.*, 1999; Lower *et al.*, 2000). The results demonstrated clearly that the clinical burden, workload and relative risk of hospital readmissions associated with post-surgical adhesions were considerable. In total, more than one in three women were readmitted on average 1.9 times during the 10-year follow-up for further surgery or for problems potentially related to adhesions (Lower *et al.*, 2000).

Whilst the SCAR study demonstrated clearly the burden of adhesions associated with open gynaecological surgery, data concerning the impact of adhesions following gynaecological laparoscopy are lacking. Laparoscopic surgery was in its

infancy in 1986 and was used primarily as a diagnostic, rather than a therapeutic, procedure. Since then, laparoscopy has become the preferred method of access for certain gynaecological interventions, and has been claimed to be associated with lower rates of adhesion development (Garrard *et al.*, 1999; Kavic, 2002). The objective of this study was to compare the epidemiology of adhesion-related readmissions in the 4 years following initial open surgery with that following initial laparoscopic gynaecological surgery.

## Methods

This study used validated patient records from the Scottish NHS Medical Record Linkage database, chosen because of its size, completeness and quality of data. The database holds one of the largest patient-linked data sets available and allows tracking of all hospital inpatient and day-case admissions in Scotland from 1981. The database is managed by the Scottish NHS Information and Statistics Division (ISD), which uses stringent quality control to ensure 99% accuracy in the linkage of patient records. Scotland provides a stable, geographically contained population ( $n = 5.1$  million) with a low annual migration rate ( $<1\%$ ) (Office for National Statistics, 2003).

Office of Population Censuses and Surveys', Fourth Edition (OPCS4) surgical procedure codes were identified in duplicate by members of the study steering group to determine open and laparoscopic gynaecological procedures (excluding Caesarean sections) that were likely to cause adhesions (Government Statistical Service, 2001). Based on these codes, two incident patient cohorts were defined within

**Table 1.** OPCS4 codes and definitions for the most common surgical procedures performed in patients undergoing initial laparoscopic gynaecological surgery in 1996–1997 ( $n = 15\,197$ )

Risk level <sup>a</sup>	Code	Procedure	No. of patients	Percentage of total no. of initial patients
High	Q493	Endoscopic drainage of cyst of ovary	263	37.3
	Q423	Endoscopic division of adhesions of peritoneum	184	26.1
	Q491	Endoscopic extirpation of lesion of ovary	53	7.52
	Other		205	29.1
<b>Total</b>			<b>705</b>	<b>100</b>
Medium	T439	Unspecified diagnostic endoscopic examination of peritoneum <sup>b</sup>	5529	99.25
	T341	Diagnostic endoscopic examination of peritoneum and biopsy of lesion of peritoneum	15	0.27
	T432	Diagnostic endoscopic examination of peritoneum and biopsy of lesion of intra-abdominal organ not elsewhere classified	2	0.04
	Other		25	0.45
<b>Total</b>			<b>5571</b>	<b>100</b>
Low	Q352	Endoscopic bilateral clipping of Fallopian tubes	5492	61.56
	Q353	Endoscopic bilateral ringing of Fallopian tubes	1041	11.67
	Q359	Unspecified endoscopic bilateral occlusion of Fallopian tubes	968	10.85
	Other		1420	15.9
<b>Total</b>			<b>8921</b>	<b>100</b>

Laparoscopic procedures were categorized according to level of risk (high, medium or low) of subsequent adhesion formation. Data are provided in terms of the number of patients undergoing each procedure and as a percentage of the total number of initial patients.

<sup>a</sup>Since OPCS4 codes for the classification of laparoscopic procedures are less specific than those describing open surgery, initial laparoscopic procedures were classified according to the associated level of risk of adhesion formation (high-, medium- or low-risk) by a panel of experts. Selections were made in duplicate and then adjudicated to ensure accuracy. The high- and low-risk groups included specific therapeutic procedures, while the medium-risk group encompassed all other interventions, including therapeutic and interventional diagnostic laparoscopies.

<sup>b</sup>Includes gynaecological laparoscopy, laparoscopy (unspecified) and peritoneoscopy not elsewhere classified.

the database, comprising those undergoing initial laparoscopic gynaecological surgery ( $n = 15\,197$ ) and those undergoing initial open gynaecological surgery ( $n = 8849$ ) in the financial year April 1996 to March 1997 (1996–1997). Adhesion-related readmissions were tracked over 4 years following initial surgery.

Initial open surgical procedures were classified by operation site, according to OPCS4 codes, as procedures performed on the Fallopian tubes, ovaries, uterus and vagina. Since OPCS4 codes for the classification of laparoscopic procedures are less specific than those describing open surgery, the laparoscopic cohort was subdivided into procedures associated with high, medium and low risks of adhesion-related readmissions. Laparoscopic adhesiolysis and cyst drainage operations constituted high-risk procedures, Fallopian tube sterilizations were categorized as low-risk procedures, and medium-risk procedures were represented by all other therapeutic and diagnostic laparoscopies (including other tubal procedures) (Table I). Most interventions in the medium-risk group (99%) were categorized under code T439: ‘unspecified diagnostic endoscopic examination of the peritoneum’.

Adhesion-related readmissions in patients within the two cohorts were determined using OPCS4 surgical codes and International Classification of Diseases, Tenth Edition (ICD10) (WHO, Office of Publications, 1992) diagnostic codes. Codes were identified individually by two surgeons and any differences were adjudicated by a third. Readmissions were classified, as described previously (Ellis *et al.*, 1999; Parker *et al.*, 2001), as: ‘directly related to adhesions’ (operative and non-operative codes specifically mentioning adhesions or adhesiolysis, e.g. operative OPCS4 codes: Q341, T413, T428; non-operative ICD10 codes: K565, K660,

N994) (Tables II and III); ‘possibly related to adhesions’ (codes referring to procedures or diagnoses which could be related to adhesions, but with no defined adhesion code, e.g. operative OPCS4 codes: Q221, T309; non-operative ICD10 codes: R102, R103, R104) (Tables II and III); or ‘re-operations (open or laparoscopic) that were unrelated to but potentially complicated by adhesions’ (e.g. OPCS4 codes: Q074, Q432, Q493) (data not shown).

The key outcome measures of the study were 1-year adhesion-related readmission rates and cumulative readmission rates over 4 years. These were determined for all surgical subgroups within the 1996–1997 open and laparoscopic cohorts.

Data were also collected for patients undergoing initial open and laparoscopic surgery in the financial years April 1997 to March 1998 (1997–1998) and April 1998 to March 1999 (1998–1999). Patients were followed up for 2 years and data were compared with the 1996–1997 cohort to identify any variation in readmissions between years and to determine time to first directly/possibly adhesion-related readmission. Where patients had a directly and a possibly related readmission within the same year, only the first event was counted when they were combined, as this was thought to best reflect the time lapse between initial surgery and the first requirement for further treatment. It should be noted that, because only the first event was counted, addition of the directly related and possibly related readmission data does not equal the sum of the directly/possibly related readmission data. The incidences of readmissions in the 3-yearly cohorts were compared using Peto’s log-rank test (Peto *et al.*, 1977).

A final objective was to assess the impact of previous surgery on adhesion-related readmissions by identifying patient

**Table II.** Numbers and percentages of patients requiring hospital readmission for events directly or possibly related to adhesions within the first year following laparoscopic gynaecological surgery in 1996–1997

	Code	Description	Number of readmissions 1 year after surgery (%)		
			High risk	Medium risk	Low risk
<b>Directly related</b>					
Operative	T413	Freeing of adhesions of peritoneum	6 (75.0)	46 (59.0)	9 (50.0)
	Q341	Open freeing of adhesions of Fallopian tube	1 (12.5)	12 (15.4)	3 (16.7)
	T428	Endoscopic division of adhesions of peritoneum	1 (12.5)	4 (5.1)	–
	Other		0 (0)	16 (20.5)	6 (33.3)
<b>Total</b>			<b>8</b>	<b>78</b>	<b>18</b>
Non-operative	N994	Postprocedural pelvic peritoneal adhesions	1 (100)	–	–
	K660	Peritoneal adhesions	–	2 (100)	1 (100)
	K565	Intestinal adhesions (bands) with obstruction			
	Other		0 (0)	0 (0)	0 (0)
<b>Total</b>			<b>1</b>	<b>2</b>	<b>1</b>
<b>Possibly related</b>					
Operative	T439	Unspecified diagnostic endoscopic examination of peritoneum	17 (53.1)	79 (35.4)	28 (33.7)
	T309	Unspecified opening of abdomen	4 (12.5)	17 (7.6)	10 (12.1)
	Q221	Bilateral salpingo-oophorectomy	3 (9.4)	29 (13.0)	6 (7.2)
	Other		8 (25)	98 (43.9)	39 (46.9)
<b>Total</b>			<b>32</b>	<b>223</b>	<b>83</b>
Non-operative	R104	Other and unspecified abdominal pain	18 (50.0)	89 (46.6)	57 (46.3)
	R103	Pain localized to other parts of lower abdomen	8 (22.2)	45 (23.6)	21 (17.1)
	R102	Pelvic and perineal pain	6 (16.7)	25 (13.1)	17 (13.8)
	Other		4 (11.2)	32 (16.8)	28 (22.8)
<b>Total</b>			<b>36</b>	<b>191</b>	<b>123</b>

Data are presented in terms of operative and non-operative causes of readmission and are categorized according to the type of procedure performed using OPCS4 and ICD10 surgical and diagnostic codes. Data are provided for the three procedures performed most commonly within each category.

**Table III.** Numbers and percentages of patients requiring hospital readmission for events directly or possibly related to adhesions within the first year following gynaecological laparotomies in 1996–1997

	Code	Description	Number of readmissions one year after surgery (%)			
			Fallopian tubes	Ovaries	Uterus	Vagina
<b>Directly related</b>						
Operative	T413	Freeing of adhesions of peritoneum	2 (50)	2 (66)	16 (64)	0 (0)
	T439 <sup>a</sup>	Unspecified diagnostic endoscopic examination of peritoneum	0 (0)	0 (0)	7 (28)	0 (0)
	T423	Endoscopic division of adhesions of peritoneum	1 (25)	0 (0)	2 (8)	0 (0)
	Q341	Open freeing of adhesions of Fallopian tubes	1 (25)	0 (0)	0 (0)	0 (0)
	T361	Omentectomy	0 (0)	1 (33)	0 (0)	0 (0)
	Other		0 (0)	0 (0)	0 (0)	0 (0)
<b>Total</b>			<b>4</b>	<b>3</b>	<b>25</b>	<b>0</b>
Non-operative	K565	Intestinal adhesions (bands) with obstruction	0 (0)	1 (50)	3 (43)	0 (0)
	K660	Peritoneal adhesions	0 (0)	1 (50)	3 (43)	0 (0)
	N998	Other postprocedural disorders of genitourinary system	0 (0)	0 (0)	1 (14)	0 (0)
	Other		0 (0)	0 (0)	0 (0)	0 (0)
<b>Total</b>			<b>0</b>	<b>2</b>	<b>7</b>	<b>0</b>
<b>Possibly related</b>						
Operative	T439	Unspecified diagnostic endoscopic examination of peritoneum	8 (29)	5 (38)	25 (26)	0
	Q074	Total abdominal hysterectomy, not elsewhere classified	–	–	25 (26)	0
	T309	Unspecified opening of abdomen	–	–	10 (10)	0
	Q413	Dye test of Fallopian tubes	6 (21)	–	–	0
	Q233	Unilateral salpingectomy not elsewhere classified	5 (18)	–	–	0
	Other		9 (32)	8 (62)	38 (38)	0
<b>Total</b>			<b>28</b>	<b>13</b>	<b>98</b>	<b>0</b>
Non-operative	R104	Other and unspecified abdominal pain	10 (37)	16 (59)	106 (50)	0 (0)
	R103	Pain localized to other parts of lower abdomen	6 (22)	2 (8)	35 (16)	0 (0)
	K566	Other and unspecified intestinal obstruction	–	–	23 (11)	0 (0)
	R102	Pelvic and perineal pain	3 (11)	–	–	0 (0)
	R11X	Nausea and vomiting	–	3 (11)	–	0 (0)
	Other		8 (30)	6 (22)	49 (23)	0 (0)
<b>Total</b>			<b>27</b>	<b>27</b>	<b>213</b>	<b>0</b>

Data are presented in terms of operative and non-operative causes of readmission and are categorized according to the type of procedure performed using OPCS4 and ICD10 surgical and diagnostic codes. Data are provided for the three procedures performed most commonly within each surgical site category.

<sup>a</sup>Code defined as a directly adhesion-related cause of readmission when associated with a directly related non-operative admission (e.g. K565, K660, N998).

subgroups within the 1996–1997 open and laparoscopic cohorts who had had no abdominopelvic surgery within the previous 5 years. To identify these patients, all OPCS4 readmission codes were matched, where possible, to the earlier OPCS3 codes, as coding had changed in 1989 (Ellis *et al.*, 1999; Lower *et al.*, 2000).

Adhesion-related readmissions in all cohorts are expressed as rates of patient readmission and rates of readmission episodes. Readmission episode rates are presented because some patients were readmitted more than once, and are expressed as a percentage of the total number of initial surgical procedures; the risk of a readmission was calculated from these percentages.

## Results

Fallopian tube sterilizations represented the most common indication for gynaecological laparoscopy (59% of all laparoscopies), and were associated with a low risk of directly adhesion-related readmissions within the first year of 1 in 500 (0.2 readmission episodes per 100 patients) (Table IV). Laparoscopic adhesiolysis, representing 4% of all laparoscopies, was predefined as high-risk, while the remaining laparoscopic procedures (37% of all laparoscopies) were categorized as medium-risk (Table IV). The predetermined high-risk and medium-risk laparoscopic groups carried similar risks of directly adhesion-related readmissions (one in 80,

1.3/100, and one in 70, 1.5/100, respectively), which were considerably greater than those associated with low-risk Fallopian tube sterilizations (Table IV). The risks of a possibly adhesion-related readmission within the first year were: high-risk, up to one in 7; medium-risk, up to one in 10; and low-risk, up to one in 40 (Table IV).

In the medium- and high-risk laparoscopic subgroups, the combined risk of a directly or possibly related readmission was highest within the first year, although readmissions continued to occur during the second, third and fourth years (Figure 1). The readmission risk remained constant over the 4 years following low-risk procedures.

Open uterine surgery represented the most common form of laparotomy (91% of procedures) and was associated with a low risk of directly adhesion-related readmissions within the first year of one in 170 (0.6 readmission episodes per 100 patients). Open surgical interventions on the ovaries and Fallopian tubes were much less common (4% and 5% of procedures, respectively), but resulted in substantially higher risks of directly adhesion-related readmissions [one in 50 (2.1/100), and one in 120 (0.9/100), respectively]. The risks of a possibly adhesion-related readmission within the first year for the high-, medium- and low-risk groups were approximately one in six, one in seven and one in 20, respectively. The risks of a directly/possibly adhesion-related readmission were highest in the first year in all open surgery categories (Figure 2).

**Table IV.** Cumulative numbers and rates of directly or possibly adhesion-related hospital readmission episodes over 4 years in patients who underwent open ( $n = 8849$ ) or laparoscopic ( $n = 15\,197$ ) gynaecological surgery in Scotland in 1996–1997

Surgery type	Initial no. of patients (%)	Cumulative no. and (rate) <sup>a</sup> of directly or possibly adhesion-related readmission episodes in the years following initial surgery			
		Year 1	Year 2	Year 3	Year 4
<b>Directly related</b>					
<i>Laparoscopy</i>					
High risk	705 (4)	9 (1.3)	14 (2.0)	17 (2.4)	21 (3.0)
Medium risk	5571 (37)	84 (1.5)	118 (2.1)	137 (2.5)	154 (2.8)
Low risk	8921 (59)	19 (0.2)	35 (0.4)	48 (0.5)	56 (0.6)
<b>Total</b>	<b>15 197 (100)</b>	<b>112 (0.7)</b>	<b>167 (1.1)</b>	<b>202 (1.3)</b>	<b>231 (1.5)</b>
<i>Laparotomy</i>					
Fallopian tubes	466 (5)	4 (0.9)	7 (1.5)	11 (2.4)	15 (3.2)
Ovaries	328 (3.7)	7 (2.1)	13 (4.0)	18 (5.5)	23 (7.0)
Uterus	8024 (91)	48 (0.6)	69 (0.9)	104 (1.3)	139 (1.7)
Vagina	31 (0.3)	0 (0.0)	0 (0.0)	3 (9.7)	3 (9.7)
<b>Total</b>	<b>8849 (100)</b>	<b>59 (0.7)</b>	<b>89 (1.0)</b>	<b>136 (1.5)</b>	<b>180 (2.0)</b>
<b>Possibly related</b>					
<i>Laparoscopy</i>					
High risk	705 (4)	101 (14.3)	146 (20.7)	186 (26.4)	233 (33.0)
Medium risk	5571 (37)	502 (9.0)	804 (14.4)	1066 (19.1)	1337 (24.0)
Low risk	8921 (59)	248 (2.8)	491 (5.5)	695 (7.8)	874 (9.8)
<b>Total</b>	<b>15197 (100)</b>	<b>851 (5.6)</b>	<b>1441 (9.5)</b>	<b>1947 (12.8)</b>	<b>2444 (16.1)</b>
<i>Laparotomy</i>					
Fallopian tubes	466 (5)	68 (14.6)	111 (23.8)	144 (30.9)	163 (35.0)
Ovaries	328 (3.7)	52 (15.9)	81 (24.7)	115 (35.1)	143 (43.6)
Uterus	8024 (91)	394 (4.9)	647 (8.1)	824 (10.3)	976 (12.2)
Vagina	31 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<b>Total</b>	<b>8849 (100)</b>	<b>514 (5.8)</b>	<b>839 (9.5)</b>	<b>1083 (12.2)</b>	<b>1282 (14.5)</b>

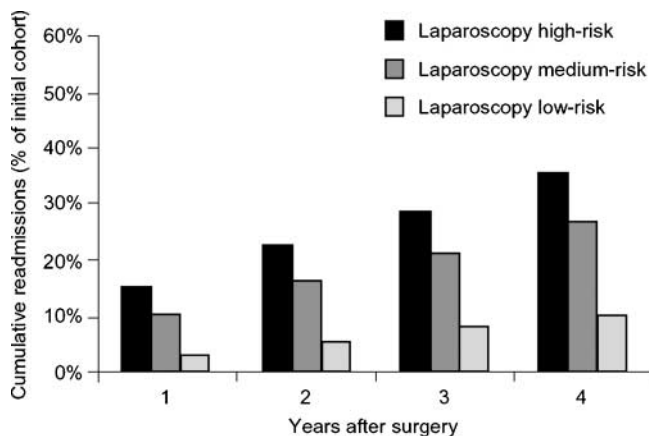
Readmissions are classified as directly or possibly related to adhesions and are presented in terms of laparoscopy (high-, medium- or low-risk procedures) and laparotomy (procedures performed on the Fallopian tubes, ovaries, uterus or vagina).

<sup>a</sup>Rate = number of readmission episodes per 100 initial patients.

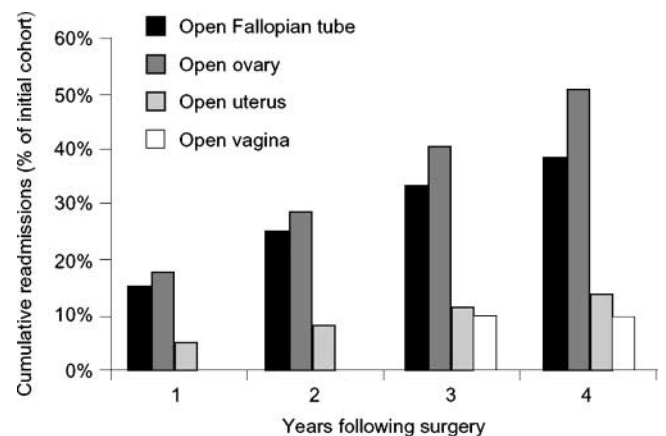
A substantial proportion (16.4%) of patients undergoing high-risk laparoscopic adhesiolysis in 1996–1997 were readmitted within 2 years for a directly or possibly adhesion-related event, while >7% of patients undergoing laparotomies were readmitted within 2 years. Data from the 1997–1998 and 1998–1999 cohorts reflected similar patterns ( $\chi^2$  for equivalence of absolute readmission rates = 2.04;  $P = 0.36$ ),

indicating that little improvement in the rate of adhesion-related readmissions had been achieved (Figure 3).

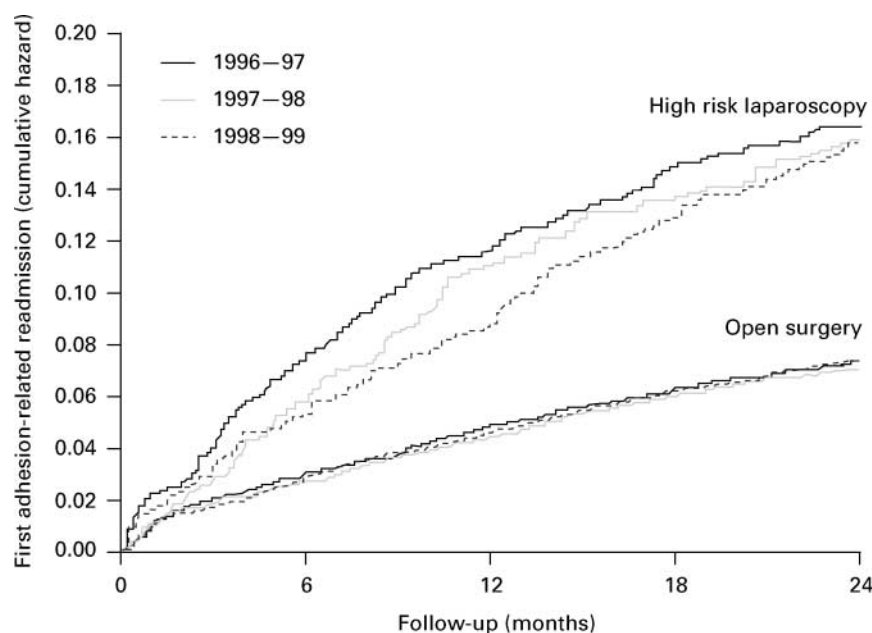
The exclusion of patients who underwent surgery within the 5 years prior to 1996–1997 had little effect on the overall rate of directly adhesion-related readmissions in the first year following laparoscopy (0.7% for all readmissions versus 0.6% excluding previous surgery), but resulted in a reduction



**Figure 1.** Cumulative rates of directly or possibly adhesion-related hospital readmission episodes over 4 years in patients who underwent gynaecological laparoscopies in Scotland in 1996–1997. Readmission rates are calculated as percentages of the total number of initial surgical procedures and are presented according to the level of risk of adhesion formation (high, medium or low). Patients who underwent previous surgery are included.



**Figure 2.** Cumulative rates of directly or possibly adhesion-related hospital readmission episodes over 4 years in patients who underwent gynaecological laparotomies in Scotland in 1996–1997. Readmission rates are calculated as percentages of the total number of initial surgical procedures and are categorized by surgical site (Fallopian tubes, ovaries, uterus, vagina). Patients who underwent previous surgery are included.



**Figure 3.** Time to first directly or possibly adhesion-related hospital readmission in patients who underwent open or high-risk laparoscopic gynaecological surgery in Scotland in 1996–1997, 1997–1998 or 1998–1999. High-risk laparoscopic procedures are classified as those associated with a high risk of subsequent adhesion formation. Adhesion-related readmissions in patients in all yearly cohorts were monitored over 2 years.

**Table V.** Cumulative numbers and rates of directly or possibly adhesion-related hospital readmission episodes over 4 years in patients who underwent open ( $n = 8849$ ) or laparoscopic ( $n = 15197$ ) gynaecological surgery in Scotland in 1996–1997

Surgery type	Initial no. of patients (%)	Cumulative no. and (rate) <sup>a</sup> of directly or possibly adhesion-related readmission episodes in the years following initial surgery, excluding surgery within the previous 5 years			
		Year 1	Year 2	Year 3	Year 4
<b>Directly related</b>					
<i>Laparoscopy</i>					
High risk	359 (3)	2 (0.6)	3 (0.8)	3 (0.8)	4 (1.1)
Medium risk	3829 (35)	47 (1.2)	69 (1.8)	80 (2.1)	93 (2.4)
Low risk	6791 (62)	12 (0.2)	22 (0.3)	27 (0.4)	31 (0.5)
<b>Total</b>	<b>10979 (100)</b>	<b>61 (0.6)</b>	<b>94 (0.9)</b>	<b>110 (1.0)</b>	<b>128 (1.2)</b>
<i>Laparotomy</i>					
Fallopian tubes	229 (4.5)	3 (1.3)	4 (1.7)	6 (2.6)	8 (3.5)
Ovaries	226 (4.3)	1 (0.4)	4 (1.8)	5 (2.2)	7 (3.1)
Uterus	4481 (91)	13 (0.3)	22 (0.5)	36 (0.8)	47 (1.0)
Vagina	9 (0.2)	0 (0.0)	0 (0.0)	3 (33.3)	3 (33.3)
<b>Total</b>	<b>4945 (100)</b>	<b>17 (0.3)</b>	<b>30 (0.6)</b>	<b>47 (1.0)</b>	<b>62 (1.3)</b>
<b>Possibly related</b>					
<i>Laparoscopy</i>					
High risk	359 (3)	46 (12.8)	68 (18.9)	85 (23.7)	110 (30.6)
Medium risk	3829 (35)	273 (7.1)	438 (11.4)	584 (15.3)	750 (19.6)
Low risk	6791 (62)	149 (2.2)	303 (4.5)	427 (6.3)	539 (7.9)
<b>Total</b>	<b>10979 (100)</b>	<b>468 (4.3)</b>	<b>809 (7.4)</b>	<b>1096 (10.0)</b>	<b>1399 (12.7)</b>
<i>Laparotomy</i>					
Fallopian tubes	229 (4.5)	28 (12.2)	46 (20.1)	57 (24.9)	63 (27.5)
Ovaries	226 (4.3)	29 (12.8)	39 (17.3)	53 (23.5)	68 (30.1)
Uterus	4481 (91)	178 (4.0)	287 (6.4)	369 (8.2)	438 (9.8)
Vagina	9 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
<b>Total</b>	<b>4945 (100)</b>	<b>235 (4.8)</b>	<b>372 (7.5)</b>	<b>479 (9.7)</b>	<b>569 (11.5)</b>

Readmissions are classified as directly or possibly related to adhesions and are presented in terms of laparoscopy (high-, medium- or low-risk procedures) and laparotomy (procedures performed on the Fallopian tubes, ovaries, uterus or vagina). Patients who underwent abdominopelvic surgery within the previous 5 years are excluded.

<sup>a</sup>Rate = number of readmission episodes per 100 initial patients.

in the readmission rate following laparotomy (0.7% versus 0.3%) (Tables IV and V). When high-risk laparoscopy alone was considered, a reduction in the 1-year directly adhesion-related readmission rate was observed (1.3% versus 0.6%) and was maintained over the next 3 years (Tables IV and V).

The most common surgical procedure defined as the cause of a directly adhesion-related readmission following initial high-, medium- and low-risk laparoscopic surgery was open surgery for the 'freeing of adhesions of the peritoneum' (high risk 75%; medium risk 59%; low risk 50%) (Table II). 'Postprocedural pelvic peritoneal adhesions' (high-risk group) and 'peritoneal adhesions' (medium- and low-risk groups) were the only directly adhesion-related causes of non-operative patient readmission in the laparoscopic cohort and were identified using ICD10 diagnostic codes (Table II).

'Freeing of adhesions of the peritoneum' represented the most common directly adhesion-related surgical cause of readmission in patients undergoing initial open surgery on the Fallopian tubes, ovaries and uterus (Table III). The most common non-operative reason for a directly adhesion-related readmission was 'intestinal adhesions with obstruction'. None of the patients undergoing initial open surgery on the vagina required readmission for directly adhesion-related operative or non-operative causes (Table III).

## Discussion

The use of laparoscopy for interventions, as well as diagnoses, has increased considerably over the last decade such that it now represents the predominant form of gynaecological surgery performed in Scotland. It has been suggested that, owing to its less invasive nature, laparoscopy may result in fewer adhesions than laparotomy during comparable surgical interventions (Garrard *et al.*, 1999; Kavic, 2002). Data from the current study support this view with respect to laparoscopic tubal sterilization procedures, which represented a considerable proportion of laparoscopies (59%), and the vast majority of low-risk laparoscopies, and were associated with a low risk of a directly related readmission within the first year of surgery (one in 500). However, for medium- and high-risk laparoscopies, which comprised over 40% of gynaecological laparoscopies, the risks of a directly adhesion-related readmission were considerable (one in 70 and one in 80, respectively) and were substantially higher than for the most common form of gynaecological laparotomy, uterine laparotomy (one in 170).

Some caution is required when interpreting data concerning medium-risk interventions, since these comprised a range of diagnostic procedures that may have identified pre-existing adhesions, adhesion-related problems or conditions associated with the formation of adhesions (such as endometriosis) rather than representing causes of adhesion formation or re-formation. Furthermore, because coding for laparoscopic surgery has lagged behind the rapid advancements in this field, appropriate codes were not available to describe certain therapeutic laparoscopic procedures, resulting in the possible inclusion of therapeutic interventions in this risk group. For these reasons, this category was associated with greater risks

of adhesion-related readmissions than might be expected. Further work is required to complete development of appropriate codes for the description of laparoscopic procedures.

OPCS4 surgical codes do not enable direct comparisons to be made between specific open and laparoscopic procedures, because laparoscopic surgical procedures have advanced beyond the limits of the OPCS4 coding system. However, evaluation of the readmission rates associated with high-risk laparoscopy (including many ovarian procedures) compared with ovarian (high-risk) laparotomy provides some indication that laparoscopy is less adhesiogenic. After 4 years, 33.0% of patients undergoing initial high-risk laparoscopy had been readmitted as a result of possibly adhesion-related events, compared with 43.6% of those undergoing initial ovarian laparotomy. However, the higher frequency with which gynaecological laparoscopies are performed may result in a higher overall burden of adhesion-related readmissions, and consequently a greater surgical workload, compared with laparotomy.

Strong evidence is available to suggest that previous laparotomy is a major risk factor for adhesion development and adhesion-related hospital readmissions (Menzie and Ellis, 1990; Ellis *et al.*, 1999; Beck *et al.*, 2000), and the present investigation provides further evidence to support this. Rates of directly adhesion-related readmissions at 1 year following both laparotomy, and particularly high-risk laparoscopy, were reduced and maintained over the following 3 years when patients who underwent surgery within the previous 5 years were excluded. A substantial proportion of high-risk laparoscopic procedures (26.1%) comprised interventions for the 'endoscopic division of adhesions of the peritoneum'. It is probable that previous surgery represented a major contributory factor in the development of such adhesions, so the exclusion of patients who had undergone surgery within the previous 5 years is likely to have reduced substantially the number of patients requiring this intervention, and thus the proportion of patients requiring hospital readmission for adhesion-related events.

The most common surgical cause of directly adhesion-related readmissions in patients undergoing both initial laparotomy and initial laparoscopy was 'freeing of adhesions of the peritoneum', whereas the most common cause in those not proceeding to surgery was 'intestinal adhesions with obstruction'. It is recognized that surgery on the female reproductive tract can cause adhesion formation at other surgical sites, including the peritoneum and small bowel (Lower *et al.*, 2000), and the current study supports these conclusions. It is interesting to note that the most common cause of non-operative readmissions possibly related to adhesions in all laparotomy subgroups was 'unspecified pain'. The association between adhesions and pain is a complex one that remains a subject of debate (Diamond and Freeman, 2001). However, numerous studies have shown a correlation between the presence of adhesions and pelvic pain, and adhesive disease is now considered to be one of the most common causes of chronic pelvic pain in women (Mishell and Davajan, 1991; Howard, 1993; diZerega, 1997; Diamond and Freeman, 2001).

In conclusion, data from the present investigation indicate that gynaecological laparoscopic and open surgical procedures are associated with comparable risks of readmission for adhesion-related problems. The current study is likely to have underestimated the number of directly adhesion-related readmissions because a substantial proportion of patients classified in the 'possibly adhesion-related' category may have had directly adhesion-related complications. Furthermore, data from the 1997–1998 and 1998–1999 cohorts show little reduction in the rate of adhesion-related readmissions compared with the 1996–1997 cohort. It should be noted that, whereas the use of adhesion-prevention adjuvants has increased in recent years, their use in Scotland at the time of this study was very limited and was mainly confined to open surgical procedures. This may explain the comparable adhesion-related readmission rates associated with the yearly cohorts. Such findings indicate that gynaecological laparoscopy and laparotomy continue to exert a considerable impact on healthcare resources in terms of an adhesion-related burden, and that this burden is unlikely to decline. A cost-effectiveness model based on lower abdominal surgery cohorts from the SCAR database predicted that the cumulative year-on-year direct costs of adhesion-related readmissions for a 10-year period would be more than £569 million (Wilson *et al.*, 2002). While similar data are, as yet, unavailable concerning gynaecological surgery, these calculations suggest that the economic costs resulting from adhesions associated with gynaecological procedures are likely to be considerable. Analyses of a similar model relating to gynaecological procedures are planned to address the issue of cost-effective interventions.

A range of strategies is available to minimize the risk of adhesion formation, including gentle tissue handling, meticulous haemostasis, minimally invasive surgery, constant irrigation and minimal foreign body contact (Holmdahl *et al.*, 1997; Ling *et al.*, 2002). However, data from the present study indicate that such strategies have had little impact to date. For women undergoing gynaecological surgery, and particularly those undergoing tubal and ovarian surgery procedures, who wish to conceive, the implementation of good surgical practice, together with the widespread adoption of adhesion-reduction agents, may help to reduce readmission rates and minimize the risk of complications such as bowel obstruction, secondary infertility and chronic pain. Through such methods, it is to be hoped that we may reduce the burden of adhesive disease for both patients and health-care providers.

### Acknowledgements

The SCAR steering group conceived the idea of establishing the gynaecological laparoscopic burden of adhesions and comparing it with the burden associated with gynaecological laparotomy. A.D.K. and A.M.C. coordinated the categorization of surgical and disease codes and the planning of data extraction. A.M.L. and R.J.S.H. selected the codes. D.C. extracted data from the patient-linked Medical Record Linkage database, assisted by A.R.F. and J.H.B. All authors interpreted the data, commented on the first draft and approved the final version. This study was supported by Shire Pharmaceuticals. A.M.L. has been involved in adhesions research for over 10 years. During this time he has been in receipt of research

funding from Ethicon, Gynecare, Genzyme and Shire Pharmaceuticals. He has received honoraria from Ethicon, Gynecare, Genzyme, Shire Pharmaceuticals, Confluent Surgical Inc, and ML Laboratories for attendance at meetings and participation in workshops on studies and adhesion-prevention products. R.J.S.H. has been involved in adhesions research for over 10 years and has received honoraria from Genzyme, Shire Pharmaceuticals and ML Laboratories for attendance at meetings and participation in workshops on studies and adhesion-prevention products. D.C., J.H.B. and A.R.F. have no competing interests. I.S.D. received funding for data extraction and analysis of the Medical Record Linkage database. A.M.C. and A.D.K. have been involved in adhesions research for over 8 years and have received consultancy funding from Genzyme, ML Laboratories and Shire Pharmaceuticals. Their time in coordinating the research project and undertaking analyses was funded by Shire Pharmaceuticals.

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### References

- Beck DE, Ferguson MA, Opelka FG, Fleshman JW, Gervaz P and Wexner SD (2000) Effect of previous surgery on abdominal opening time. *Dis Colon Rectum* 43,1749–1753.
- Coleman MG, McLain AD and Moran BJ (2000) Impact of previous surgery on time taken for incision and division of adhesions during laparotomy. *Dis Colon Rectum* 43,1297–1299.
- Diamond MP and Freeman ML (2001) Clinical implications of postsurgical adhesions. *Hum Reprod Update* 7,567–576.
- diZerega GS (1997) Biochemical events in peritoneal tissue repair. *Eur J Surg Suppl* 577 163,10–16.
- diZerega GS and Campeau JD (2001) Peritoneal repair and post-surgical adhesion formation. *Hum Reprod Update* 7,547–555.
- Duffy D and diZerega GS (1996) Adhesion controversies: pelvic pain as a cause of adhesions, crystalloids in preventing them. *J Reprod Med* 41,19–26.
- Ellis H (1998) The magnitude of adhesion related problems. *Ann Chir Gynaecol* 87,9–11.
- Ellis H, Moran BJ, Thompson JN, Parker MC, Wilson MS, Menzies D, McGuire A, Lower AM, Hawthorn RJ, O'Brien F *et al.* (1999) Adhesion-related hospital readmissions after abdominal and pelvic surgery: a retrospective cohort study. *Lancet* 353,1476–1480.
- Garrard CL, Clements RH, Nanney L, Davidson JM and Richards WO (1999) Adhesion formation is reduced after laparoscopic surgery. *Surg Endosc* 13,10–13.
- Government Statistical Service (2001) Hospital Episode Statistics. In England: Financial Year 1999–00. Department of Health, London, UK.
- Holmdahl L, Risberg B, Beck DE, Burns JW, Chegini N, diZerega GS and Ellis H (1997) Adhesions: pathogenesis and prevention—panel discussion and summary. *Eur J Surg Suppl* 577,56–62.
- Howard FM (1993) The role of laparoscopy in chronic pelvic pain: promise and pitfalls. *Obstet Gynecol Surv* 48,357–387.
- Ivarsson ML, Holmdahl L, Franzen G and Risberg B (1997) Cost of bowel obstruction resulting from adhesions. *Eur J Surg* 163,679–684.
- Kavic M (2002) Adhesions and adhesiolysis: the role of laparoscopy. *JSL* 6,99–109.
- Liakakos T, Thomakos N, Fine PM, Dervenis C and Young RL (2001) Peritoneal adhesions: etiology, pathophysiology, and clinical significance. Recent advances in prevention and management. *Dig Surg* 18,260–273.
- Ling FW, DeCherney AH, Diamond MP, diZerega GS and Montz FJ (2002) The Challenge of Pelvic Adhesions. In *Strategies for Prevention and Management. Educational Series on Women's Health Issues*, Association of Professors of Gynecology and Obstetrics, Crofton, MD, USA.
- Lower AM, Hawthorn RJ, Ellis H, O'Brien F, Buchan S and Crowe AM (2000) The impact of adhesions on hospital readmissions over ten years



- after 8849 open gynaecological operations: an assessment from the Surgical and Clinical Adhesions Research Study. *BJOG* 107,855–862.
- Menzies D and Ellis H (1990) Intestinal obstruction from adhesions—how big is the problem? *Ann R Coll Surg Engl* 72,60–63.
- Menzies D, Parker M, Hoare R and Knight A (2001) Small bowel obstruction due to postoperative adhesions: treatment patterns and associated costs in 110 hospital admissions. *Ann R Coll Surg Engl* 83,40–46.
- Mishell DR and Davajan V (1991) Evaluation of the infertile couple. In Mishell DR, Davajan V, and Lobo RA (eds) *Infertility Contraception and Reproductive Endocrinology*. Blackwell Scientific Publications Inc, Cambridge, MA, USA, pp. 557–570.
- Monk BJ, Berman ML and Montz FJ (1994) Adhesions after extensive gynecologic surgery: Clinical significance, etiology, and prevention. *Am J Obstet Gynecol* 170,1396–1403.
- Office for National Statistics (2003) *Population Trends* No. 113. National Statistics, London, UK.
- Parker MC, Ellis H, Moran BJ, Thompson JN, Wilson MS, Menzies D, McGuire A, Lower AM, Hawthorn RJ, O'Brien F et al. (2001) Postoperative adhesions: ten-year follow-up of 12,584 patients undergoing lower abdominal surgery. *Dis Colon Rectum* 44,822–829.
- Peto R, Pike MC, Armitage P, Breslow NE, Cox DR, Howard SV, Mantel N, McPherson K, Peto J and Smith PG (1977) Design and analysis of randomized clinical trials requiring prolonged observation of each patient. II. Analysis and examples. *Br J Cancer* 35,1–39.
- Ray NF, Denton WG, Thamer M, Henderson SC and Perry S (1998) Abdominal adhesiolysis: inpatient care and expenditures in the United States in 1994. *J Am Coll Surg* 186,1–9.
- van der Krabben AA, Dijkstra FR, Nieuwenhuijzen M, Reijnen MM, Schaapveld M and van Goor H (2000) Morbidity and mortality of inadvertent enterotomy during adhesiotomy. *Br J Surg* 87,467–471.
- WHO, Office of Publications (1992) *International Statistical Classification of Diseases and Related Health Problems, 1989 Revision*. World Health Organization, Geneva, Switzerland.
- Wilson MS, Menzies D, Knight A and Crowe AM (2002) Demonstrating the clinical and cost effectiveness of adhesion reduction strategies. *Colorectal Dis* 4,355–360.

*Submitted on February 9, 2004; accepted on April 23, 2004*