Bile duct reconstruction following laparoscopic cholecystectomy in England

Y. El-Dhuwaib1 · J. Slavin1,4 · D. J. Corless4 · I. Begaj3 · D. Durkin2 · M. Deakin1,2

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Abstract

Objectives To determine the incidence of bile duct reconstruction (BDR) following laparoscopic cholecystectomy (LC) and to identify associated risk factors.

Background Major bile duct injury (BDI) requiring reconstruction is a serious complication of cholecystectomy.

Methods All LC and attempted LC operations in England between April 2001 and March 2013 were identified. Patients with malignancy, a stone in bile duct or those who underwent bile duct exploration were excluded. This cohort of patients was followed for 1 year to identify those who underwent BDR as a surrogate marker for major BDI. Logistic regression was used to identify factors associated with the need for reconstruction.

Results In total, 572,223 LC and attempted LC were performed in England between April 2001 and March 2013. Five hundred (0.09 %) of these patients underwent BDR. The risk of BDR is lower in patient that do not have acute cholecystitis [odds ratio (OR) 0.48 (95 % CI 0.30–0.76)]. The regular use of on-table cholangiography (OTC) [OR 0.69 (0.54–0.88)] and high consultant caseload [OR 0.56 (0.39–0.54)] reduced the risk of BDR. Patients who underwent BDR were 10 times more likely to die within a year than those who did not require further surgery (6 vs. 0.6 %).

Conclusions The rate of BDR following laparoscopic cholecystectomy in England is low (0.09 %). The study suggests that OTC should be used more widely and provides further evidence in support of the provision of LC services by specialised teams with an adequate caseload (>80).

Keywords Bile duct injury · Bile duct reconstruction · Hospital Episode Statistics data · Laparoscopic cholecystectomy · On-table cholangiography

Laparoscopic cholecystectomy (LC) is a common operation, with over 60,000 operations undertaken each year in England. Based on conversion rate, it has been suggested that LC should be undertaken by high-volume surgeons [1].

Bile duct injury (BDI) is a rare but serious complication of cholecystectomy, and the reported incidence following LC is between 0.1 and 1.5 % [2–8]. Gallrick et al showed that the overall incidence of BDI was 1.5 %; however, they included patients with bile leaks, partial duct injury, and non-specific injuries that would not have required reconstruction. The rate decreases to 0.1 % if only the most serious cases of BDI are included [6]. BDI is associated with significant morbidity and mortality. Early complications include collections or peritonitis and if not treated sepsis, multiorgan failure and death [9]. Patients who sustain a BDI are also at risk of long-term problems including strictures, cholangitis and secondary biliary cirrhosis, requiring multiple hospital admissions, a shortened life expectancy and transplantation. The reported perioperative mortality rate following BDI varies between 0 and

M. Deakin
Mark.Deakin@uhns.nhs.uk

1 The Institute for Science and Technology in Medicine, Keele University, Stoke-on-Trent, UK
2 Department of Surgery, Royal Stoke University Hospital, Stoke-on-Trent ST4 6RG, UK
3 Health Informatics Department, University Hospitals Birmingham, Birmingham, UK
4 Department of Surgery, Mid Cheshire Hospitals NHS Foundation Trust, Crewe, UK

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7.2 % [5, 10–12] with a 1-year mortality of 3.9 % [6]. A review of the literature showed (602 BDI from 15 studies) that the adjusted hazard ratio of death in the longer term in those sustaining BDI compared to those without BDI following LC or attempted LC was 2.79 (95 % CI 2.77–2.81) [4].

This study investigates bile duct reconstruction (BDR) following LC or attempted LC in England as a surrogate marker for major bile duct injury requiring reconstruction.

Methods

Hospital Episode Statistics (HES) data were obtained from the National Health Service Information Centre (NHSIC) and imported into Microsoft SQL server for analysis. All patients who underwent LC or attempted LC between April 2001 and March 2013 were identified by searching the operative fields for the OPCS-4 (Office of Population Censuses and Surveys 4) codes J18* (cholecystectomy) and the corresponding laparoscopic codes.

Using diagnostic codes, International classification of Diseases version 10 (ICD 10), patients undergoing surgery for benign biliary disease of the gall bladder were identified. Those who underwent LC or attempted LC for a stone in the bile duct or for a malignant neoplasm of the liver, gall bladder, biliary tree or pancreas were excluded.

Factors that may affect the risk of BDR were divided into patient and non-patient groups. Patient-related factors studied included age, gender, acute pancreatitis, acute cholecystitis, comorbidity and deprivation index score. The Charlson comorbidity score was calculated using methods described by Dr Foster [13]. The deprivation index score was used as described in the English indices of deprivation [14].

Non-patient-related factors included were consultant caseload, hospital volume, consultant conversion rate, whether a trust was a regional hepatopancreatobiliary (HPB) centre and consultant rate of use of intraoperative cholangiography (IOC). Definitions are summarised in Table 2.

Mortality was assessed for all patients using data derived from the Office of National Statistics. One-year
Table 1 Operative and diagnostic codes used in this study

| Codes used for cholecystectomy                                      | Description                                                      |
|---------------------------------------------------------------------|------------------------------------------------------------------|
| J181                                                                | Total cholecystectomy and surrounding tissue                     |
| J183                                                                | Total cholecystectomy                                            |
| J185                                                                | Partial cholecystectomy                                          |
| J188                                                                | Other excision of gall bladder                                   |
| J189                                                                | Unspecified excision of gall bladder                             |

| Codes used for intraoperative cholangiography                        | Description                                                      |
|---------------------------------------------------------------------|------------------------------------------------------------------|
| J372                                                                | Operative cholangiography through cystic duct                    |
| J373                                                                | Direct puncture operative cholangiography                        |

| Codes used for laparoscopic surgery and conversion                   | Description                                                      |
|---------------------------------------------------------------------|------------------------------------------------------------------|
| Y718                                                                | Failed minimal access approach converted to open (before 2006)   |
| Y714                                                                | Failed minimal access approach converted to open (after 2006)    |
| Y508                                                                | Laparoscopic approach to abdominal cavity (before 2006)          |
| Y75*                                                                | Laparoscopic approach to abdominal cavity (assisted, robotic, hand-assisted and other approach) (after 2006) |

| Codes used for diagnosis                                             | Description                                                      |
|---------------------------------------------------------------------|------------------------------------------------------------------|
| K800                                                                | Calculus of gall bladder with acute cholecystitis                 |
| K801                                                                | Calculus of gall bladder with other cholecystitis                 |
| K802                                                                | Calculus of gall bladder without cholecystitis                    |
| K808                                                                | Other cholelithiasis                                              |
| K810                                                                | Acute cholecystitis                                               |
| K811                                                                | Chronic cholecystitis                                             |
| K818                                                                | Other cholecystitis                                               |
| K819                                                                | Unspecified cholecystitis                                        |
| K82*                                                                | Other diseases of gall bladder                                    |
| K832                                                                | Perforation of bile duct                                         |
| K85*                                                                | Acute pancreatitis                                                |

| Codes used for exclusion in the diagnosis fields                    | Description                                                      |
|---------------------------------------------------------------------|------------------------------------------------------------------|
| K803                                                                | Calculus of bile duct with cholangitis                            |
| K804                                                                | Calculus of bile duct with cholecystitis                          |
| K805                                                                | Calculus of bile duct without cholecystitis or cholangitis        |
| K830                                                                | Cholangitis                                                      |
| K823                                                                | Fistula of gall bladder                                           |
| K831                                                                | Obstruction of bile duct                                         |
| K833                                                                | Fistula of bile duct                                              |
| C22*                                                                | Malignant neoplasm of liver and intrahepatic duct                 |
| C23                                                                 | Malignant neoplasm of gall bladder                                |
| C24*                                                                | Malignant neoplasm of other parts biliary tract                   |
| C25*                                                                | Malignant neoplasm of pancreas                                    |

| Codes used for exclusions in the operative fields                   | Description                                                      |
|---------------------------------------------------------------------|------------------------------------------------------------------|
| J182                                                                | Total cholecystectomy and exploration of common bile duct        |
| J184                                                                | Partial cholecystectomy and exploration of common bile duct      |

| Codes used to identify bile duct reconstruction                     | Description                                                      |
|---------------------------------------------------------------------|------------------------------------------------------------------|
| J27.2                                                                | Partial excision of bile duct and anastomosis of bile duct to duodenum |
| J27.3                                                                | Partial excision of bile duct and anastomosis of bile duct to jejunum |
| J27.4                                                                | Partial excision of bile duct and end-to-end anastomosis of bile duct |
| J29.1                                                                | Anastomosis of hepatic duct to transposed jejunum and insertion of tubal prosthesis HFQ |
| J29.2                                                                | Anastomosis of hepatic duct to jejunum NEC                        |
| J30.1                                                                | Anastomosis of common bile duct to duodenum                       |
| J30.2                                                                | Anastomosis of common bile duct to transposed jejunum             |
| J30.3                                                                | Anastomosis of common bile duct to jejunum NEC                    |
| J32.1                                                                | Reconstruction of bile duct                                      |
| J32.2                                                                | Reanastomosis of bile duct                                       |
mortality was then calculated for patients with or without BDR.

**Statistics**

Univariate analysis and multivariate analysis (logistic regression) were used to investigate which factors are associated with a risk of bile duct reconstruction.

A funnel plot was used to examine institutional variation and shows the standardised ratio of BDRs at 1 year following LC plotted against the number of expected BDRs (Fig. 2). The expected number of BDRs is derived using a multivariate logistic regression model that accounts for patient-related factors. The BDR ratio was calculated by dividing observed BDR per year over expected BDR per year multiplied by 100. Each hospital is represented by a blue dot. The dotted lines show the lower and upper 95% control limit and the solid lines the upper and lower 99.8% control limit as described by Eayers [15]. If a hospital falls outside the 99.8% control limit, this is considered to be the result of special cause variation and would usually require further investigation.

**Results**

In total, 572,223 LCs and attempted LCs were performed in England between April 2001 and March 2013 (Table 3). More than half (56%) were undertaken in patients under 55 years of age, while 7.2% were performed in patients above 75 years. Just over three quarters of LCs or attempted LCs were undertaken in females. The majority of LCs was performed electively (89%). Almost a third of emergency LCs were performed for acute cholecystitis and 13.3% for acute pancreatitis. The number of LCs performed in the NHS in England almost doubled from 32,086 in 2001/2002 to 62,020 during 2012/2013. The overall conversion rate of LC in England is 4.3%. One-year mortality rate following LC in England is 0.6%. Around half of the patients who underwent LC or attempted LC had their surgery under the care of a consultant surgeon who performs between 20 and 80 cases a year, and a quarter of patients underwent surgery under care of consultants who perform less than 20 or more than 80 cases a year.

Five hundred patients underwent BDR within one year of a LC (0.09%) (Table 3). Patients who underwent BDR following LC were 10 times more likely to die within a year of the index cholecystectomy (6 vs 0.6%). There is a trend towards a lower rate of BDR (Fig. 3).
Table 3 Demographics of study cohort

|                                | No. of cholecystectomies | Bile duct reconstruction within 1 year | %  |
|--------------------------------|--------------------------|----------------------------------------|----|
| Total                          | 572,233                  | 500                                    | 0.09 |
| Age group                      |                          |                                        |    |
| <55                            | 319,632                  | 220                                    | 0.07 |
| 55–64                          | 119,663                  | 114                                    | 0.10 |
| 65–74                          | 90,700                   | 95                                     | 0.10 |
| 75+                            | 41,907                   | 71                                     | 0.17 |
| Not recorded                   | 331                      | 0                                      | 0.00 |
| Gender                         |                          |                                        |    |
| Males                          | 135,478                  | 178                                    | 0.13 |
| Females                        | 436,606                  | 322                                    | 0.07 |
| Not recorded                   | 149                      | 0                                      | 0.00 |
| Ethnicity                      |                          |                                        |    |
| White                          | 451,869                  | 405                                    | 0.09 |
| Asian or Asian British         | 20,106                   | 25                                     | 0.12 |
| Black or Black British         | 8,128                    | 7                                      | 0.09 |
| Other ethnic groups            | 5,657                    | 9                                      | 0.16 |
| Mixed                          | 2,315                    | 3                                      | 0.13 |
| Chinese                        | 1,059                    | 0                                      | 0.00 |
| Unknown                        | 83,099                   | 51                                     | 0.06 |
| Deprivation (quintile)         |                          |                                        |    |
| 1-Most deprived                | 122,185                  | 100                                    | 0.08 |
| 2                              | 118,715                  | 114                                    | 0.10 |
| 3                              | 116,686                  | 101                                    | 0.09 |
| 4                              | 110,811                  | 96                                     | 0.09 |
| 5-Least deprived               | 100,190                  | 83                                     | 0.08 |
| Not recorded                   | 3,646                    | 6                                      | 0.16 |
| Tertiary centre                |                          |                                        |    |
| No                             | 461,346                  | 386                                    | 0.08 |
| Yes                            | 110,887                  | 114                                    | 0.10 |
| Admission method               |                          |                                        |    |
| Elective                       | 510,260                  | 435                                    | 0.09 |
| Emergency                      | 61,406                   | 65                                     | 0.11 |
| Transfer                       | 431                      | 0                                      | 0.00 |
| Other                          | 136                      | 0                                      | 0.00 |
| Acute cholecystitis (index admission) |                |                                        |    |
| No                             | 551,812                  | 478                                    | 0.09 |
| Yes                            | 20,421                   | 22                                     | 0.11 |
| Acute pancreatitis (index admission) |               |                                        |    |
| No                             | 564,077                  | 493                                    | 0.09 |
| Yes                            | 8,156                    | 7                                      | 0.09 |
| Year of index admission        |                          |                                        |    |
| 2001/2002                      | 32,086                   | 28                                     | 0.09 |
| 2002/2003                      | 37,290                   | 36                                     | 0.10 |
| 2003/2004                      | 40,824                   | 53                                     | 0.13 |
| 2004/2005                      | 39,533                   | 33                                     | 0.08 |
| 2005/2006                      | 42,573                   | 35                                     | 0.08 |
| 2006/2007                      | 45,049                   | 50                                     | 0.11 |
| 2007/2008                      | 50,702                   | 43                                     | 0.08 |
| 2008/2009                      | 50,689                   | 49                                     | 0.10 |
| 2009/2010                      | 53,748                   | 32                                     | 0.06 |
Patient-related factors

Univariate analysis showed that patient-related factors including increasing age and male sex were significantly associated with bile duct reconstruction. However, multivariate analysis did not confirm these associations, suggesting that other factors may be responsible for these findings (Table 4). Only patients with acute cholecystitis who undergo LC on the index admission were found by both univariate and multivariate analyses to have an increased risk of BDR.

Non-patient-related factors

Univariate and multivariate analyses showed that high-volume consultant caseload >80 LC/year is associated with a lower rate of BDR. There was a strong association between conversion and BDR ($p < 0.001$), which may be due to surgeons converting when they suspect a BDI. Therefore, we used consultant conversion rate in the year before rather than conversion in an individual case. There was no association between consultant conversion rate in the previous year and BDR following LC or attempted LC.

Similarly, there was a strong association between the use of OTC and BDR in individual cases ($p < 0.001$). This may be due to surgeons using OTC when they suspect a BDI, but when consultants are divided into tertiles on the basis of their use of OTC in the year before the index case, those who use it more frequently have a lower rate of patients subsequently undergoing bile duct reconstruction, odds ratio 0.69 with 95% CI (0.54–0.88).

Trust caseload volume was divided into low-volume providers <200 LC/year, intermediate-volume provider between 200 and 500 LC/year and high-volume providers, which perform more than 500 LC/year. Univariate and multivariate analyses did not show any association between Trust caseload volume and BDR.

There was no difference in the rate of BDR following LC or attempted LC if the index procedure was undertaken in an HPB centre as compared to a non-HPB centre.

A funnel plot was used to examine the rate of BDR following LC/attempted LC in individual trusts. All hospitals were within the 95% confidence interval. Most BDRs were performed in the hospital in which an injury occurs rather than a regional centre (Table 5).

Discussion

This is the largest study of its kind in the literature that examines BDR following LC or attempted LC. It investigates all patients who underwent LC in England over a
12-year period. The apparent rate of BDR and therefore presumed bile duct injury is in keeping with published series (the previous literature for major injuries). Patient-related factors associated with BDR include cholecystitis on the index admission. Non-patient-related factors associated with a lower reconstruction rate include a high consultant cholecystectomy caseload and regular use of OTC. There is a tenfold increase in mortality at 1 year in patients who have undergone a BDR (at 1 year), demonstrating how serious this complication can be.

This study suggests that the incidence of BDR following LC in England is low (0.09 %) with only 500 cases over a 12-year period. Data from other registries show that the incidence of BDI in Germany is 0.1 % (172,368 LC) [2]; in Denmark 0.15 % (23,672 LC) [3]; in the USA between 0.06 and 0.5 % [4, 16]; in Finland 0.82 % (6733 LC) [5]; and in Sweden 1.5 % (51,041 LC) [6], although major BDI in this study accounts for only 0.1 %. However, researchers have to understand that different definitions of what constitutes BDI make comparative analysis difficult. Other reports from large single-centre studies (over 10,000 LC) showed the incidence of BDI is between 0.19 % [8] and 0.24 % [7]. There was a trend towards a reducing need for BDR during the study period, which may represent an increased awareness of methods of safe cholecystectomy.

The study has a number of limitations. There are no codes for BDI, and we therefore used codes for bile duct reconstruction. Other studies using registry data have used

| Table 4 Multivariate analysis of factors that may be associated with bile duct reconstruction following LC or attempted LC | Odds ratio—bile duct reconstruction | SE | z | p value | 95 % CI |
|---------------------------------------------------------------|-----------------------------------|----|----|---------|--------|
| Age group <55                                                 | 1.00                              |    |    |         |        |
| 55–64                                                        | 0.97                              | 0.12| −0.27| 0.787   | 0.76   | 1.23   |
| 65–74                                                        | 0.86                              | 0.12| −1.09| 0.274   | 0.67   | 1.12   |
| 75+                                                          | 1.22                              | 0.18| 1.33 | 0.185   | 0.91   | 1.63   |
| Gender females                                               | 0.89                              | 0.09| −1.1 | 0.269   | 0.73   | 1.09   |
| Deprivation                                                  |                                    |    |    |         |        |
| 1-Most deprived                                              | 1.00                              |    |    |         |        |
| 2                                                            | 1.24                              | 0.18| 1.52 | 0.128   | 0.94   | 1.64   |
| 3                                                            | 1.13                              | 0.17| 0.85 | 0.396   | 0.85   | 1.51   |
| 4                                                            | 1.15                              | 0.17| 0.96 | 0.335   | 0.86   | 1.55   |
| 5-Least deprived                                             | 1.11                              | 0.17| 0.65 | 0.513   | 0.81   | 1.51   |
| No acute cholecystitis                                       | 0.48                              | 0.11| −3.12| 0.002   | 0.30   | 0.76   |
| Acute pancreatitis                                           | 0.81                              | 0.34| −0.5 | 0.620   | 0.36   | 1.83   |
| Charlson score                                               | 0.94                              | 0.08| −0.76| 0.445   | 0.80   | 1.10   |
| Cholangiography (index admission)                            | 2.73                              | 0.37| 7.45 | 0.000   | 2.10   | 3.56   |
| Converted procedure                                          | 22.89                             | 2.33| 30.75| 0.000   | 18.75  | 27.94  |
| No. procedures per consultant (prev. year, exc. 2001/2002)   |                                    |    |    |         |        |
| Low volume <20                                               | 1.00                              |    |    |         |        |
| Middle volume 20–80                                           | 0.80                              | 0.11| −1.64| 0.100   | 0.62   | 1.04   |
| High volume >80                                              | 0.56                              | 0.10| −3.19| 0.001   | 0.39   | 0.80   |
| No. procedures per provider (previous year, exc. 2001/2002)  |                                    |    |    |         |        |
| Low volume <200                                              | 1.00                              |    |    |         |        |
| Middle volume 200–500                                         | 1.07                              | 0.18| 0.37 | 0.710   | 0.76   | 1.49   |
| High volume >500                                             | 1.31                              | 0.24| 1.44 | 0.150   | 0.91   | 1.89   |
| Tertiary hospital                                            | 1.19                              | 0.14| 1.51 | 0.130   | 0.95   | 1.49   |
| Consultant conversion rate—quartiles (previous year, exc. 2001/2002) |                  |    |    |         |        |
| 1-Lowest quartile                                            | 1.00                              |    |    |         |        |
| 2                                                            | 1.05                              | 0.20| 0.24 | 0.808   | 0.72   | 1.54   |
| 3                                                            | 1.07                              | 0.16| 0.47 | 0.636   | 0.80   | 1.43   |
| 4-Highest                                                    | 0.95                              | 0.13| −0.36| 0.721   | 0.74   | 1.24   |
| Consultant cholangiography rate—tertiles (previous year, exc. 2001/2002) |                  |    |    |         |        |
| 1-Lowest tertile                                             | 1.00                              |    |    |         |        |
| 2                                                            | 1.17                              | 0.18| 1    | 0.318   | 0.86   | 1.58   |
| 3                                                            | 0.69                              | 0.09| −2.98| 0.003   | 0.54   | 0.88   |
similar methodology [2–4, 17]. Patients who sustain a BDI and die without surgical intervention will not be included in this analysis. This study only identifies major duct injuries that require reconstruction, whereas minor injuries that require simple repair, drainage or ERCP and stenting are not included. Therefore, the study underestimates the incidence of BDI. Nevertheless, most minor injuries are associated with a lower rate of complications and lower long-term morbidity. However, the study does include those patients who fail to respond to ERCP and stenting or who develop stenosis of bile duct that requires delayed (within a year) surgical reconstruction.

The study uses HES data which are administrative data that rely on the accuracy of clinical coding. A recent systematic review shows that coding accuracy is improving and following the introduction of payment by results in 2002 the accuracy of coding for primary diagnoses has improved from 73.8 % (IQR 59.3–92.1 %) to 96.0 % (IQR 89.3–96.3) [18]. Further studies based on HES are cohort studies; they differ from the usual cohort studies in that they represent almost all activity within the area of study in England. One also has to consider the context of conclusions that are drawn from studies using HES. If findings are of a general nature, then even a relatively high coding error rate at some hospitals or even all hospitals will not detract markedly from the overall conclusions if significant deviation can be shown [19]. Thus, studies based on HES data may actually be good at dealing with research questions such as those posed in this study but are less good at identifying variations in care between individual trusts or clinicians [20]. We have not attempted to analyse the incidence of minor bile duct injuries as the coding issues are complex and we feel that it would be difficult to draw valid conclusions from the data.

Cholecystectomy is considered by many surgeons to be more difficult in male as compared to female patients, and this may lead to a higher complication rates. Our data showed male gender is associated with almost double the rate of BDR (0.13 %) compared to female patients (0.07 %). However, this difference becomes statistically insignificant when an adjustment is made for other factors.

Age has been shown to be an independent risk factor for BDI [21] and mortality following BDI [4]. Associated comorbidities, frailty, use of anticoagulants and previous abdominal surgery have been postulated to contribute to the increase in risk in the elderly [21]. Data from this study showed BDR following LC in elderly patients >75 years (0.17 %) was more than that in those below 55 years (0.07 %). However, multivariate analysis did not reveal any significant difference with age which implies that other factors are more important.

The calibre of the bile duct increases with age which may make simple repair easier in older patients [22, 23]. Whether simple suture repair of the bile duct can be accomplished depends on many other factors, for example, the presence of a clean laceration identified at the same time of surgery together with a wide calibre bile duct. Several studies [24–26] have shown that bile duct injury repaired at an HPB centre is associated with a better outcome as compared to those repaired in a general hospital. Data from this study showed more than half of the injuries were repaired locally. Centralisation of HPB services has progressed rapidly in the UK with most major resections occurring in HPB centres during the study period. Many of those surgeons who used to perform resectional biliary surgery may still practice in their local hospital. Further some regions offer an outreach service where a BDI injury may be treated in the local hospital by a surgeon from the regional unit.

### Table 5: Bile duct reconstruction at index or another hospital

| Financial year (index admission) | No. bile duct reconstructions | Number performed at different hospital | % Bile duct repairs not in same hospital |
|----------------------------------|------------------------------|----------------------------------------|----------------------------------------|
| 2001/2002                        | 28                           | 10                                     | 35.7                                   |
| 2002/2003                        | 36                           | 12                                     | 33.3                                   |
| 2003/2004                        | 53                           | 15                                     | 28.3                                   |
| 2004/2005                        | 33                           | 14                                     | 42.4                                   |
| 2005/2006                        | 35                           | 16                                     | 45.7                                   |
| 2006/2007                        | 50                           | 24                                     | 48.0                                   |
| 2007/2008                        | 43                           | 13                                     | 30.2                                   |
| 2008/2009                        | 49                           | 19                                     | 38.8                                   |
| 2009/2010                        | 32                           | 11                                     | 34.4                                   |
| 2010/2011                        | 49                           | 18                                     | 36.7                                   |
| 2011/2012                        | 52                           | 21                                     | 40.4                                   |
| 2012/2013                        | 40                           | 22                                     | 55.0                                   |
Most surgeons in the UK perform OTC selectively. Large studies based on registry data have produced conflicting results. While some show that the risk of BDI decreases when OTC is performed, [6, 17, 27–29] others, including a systematic review [30] show no benefit [31]. The study showed that surgeons who use OTC more frequently have a lower rate of BDR following LC.

The study did not show any difference in BDR following LC between low- and high-volume NHS providers or HPB centres and general hospitals, suggesting that all NHS providers deliver a satisfactory cholecystectomy service. However, it appears consultant caseload is an independent risk factor for BDR following LC. Surgeons who perform 80 LC/year or more have a lower rate of BDR than low-volume surgeons. Further BDR appears to be more common in patients who undergo cholecystectomy on an index emergency admission with acute cholecystitis.

These results suggest that more widespread use of OTC could also help to reduce the incidence of BDI. They do not support centralisation of cholecystectomy services; however, they do suggest that to avoid major bile duct injury the development of dedicated teams in each hospital with an adequate LC caseload (>80) may help to reduce the incidence of this complication and further suggests that the occasional operator should reconsider their practice especially in emergency patients.

**Author’s contribution** All authors have made substantial contributions to the conception or design of the work and drafting the work or revising it critically for important intellectual content. All authors approved the final version to be published. An agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

**Compliance with ethical standards**

**Disclosures** Y. El-Dhuwaib, J. Slavin, D. J. Corless, I. Begaj, D. Durkin and M. Deakin have declare that they have no financial interests (including employment, significant share ownership, patent rights, consultancy, research funding, speaker’s fees) in a company or institution that might benefit from the publication of the submitted article.

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