Impact of board certification system and adherence to the clinical practice guidelines for liver cancer on post-hepatectomy risk-adjusted mortality rate in Japan: A questionnaire survey of departments registered with the National Clinical Database

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Abstract
Background: It is unclear to what extent a board certification system and implementation of clinical guidelines improves the quality of hepatectomy.
Methods: A web-based questionnaire survey was administered to departments registered with the National Clinical Database (NCD) in Japan between 1 October 2014 and 31 January 2015. Quality indicators (QIs), including affiliations with academic societies, numbers of board-certified doctors affiliated with each institute, and adherence to clinical practice guidelines for hepatocellular carcinoma, were evaluated by calculating risk-adjusted odds ratios (AORs) for 90-day postoperative mortality of patients who had undergone hepatectomy in 2013 and 2014.
Results: Of 1255 departments that had registered at least one hepatectomy in NCD, 592 departments, performing 8601 hepatectomies in total, responded to the questionnaire. AORs were significantly lower in departments that were certified as training...
1 | INTRODUCTION

The safety and efficacy of hepatectomy have improved dramatically in recent years, enabling broadening of the indications for this procedure. However, nationwide studies using the National Clinical Database (NCD) in Japan have demonstrated that post-hepatectomy mortality rates are relatively high compared with those of other gastroenterological surgical procedures, such as gastrectomy and colorectal surgery.

Donabedian et al have proposed a three-component model for measuring the quality of health care: structure, process, and outcome. In this model, “structure” is defined as settings, qualifications of providers, and administrative systems through which care takes place; “process” as the components of care delivered; and “outcome” as recovery, restoration of function, and survival. In this model, certain quality indicators (QIs) for each of the three above-mentioned components are used to assess quality of care.

A three-stage board certification system for the education and training of highly skilled surgeons has been established in Japan. The Japan Surgical Society (JSS), Japanese Society of Gastroenterological Surgery (JSGS), and Japanese Society of Hepato-Biliary-Pancreatic Surgery (JSHBPS) are responsible for the first, second, and third levels of accreditation in the field of hepatectomy, respectively. Each of these academic societies accredits both training institutes and certified surgeons. Additionally, participation in provision of multidisciplinary treatment by hepatologists certified by the Japanese Society of Hepatology (JSH) and oncologists certified by the Japanese Board of Cancer Therapy (JBCT), classified as a “structure” factor, may improve the outcomes of hepatectomy for liver cancer. These board certification systems may be considered in constructing structure-related QIs.

Implementation of standards of care may play a role in improving quality of health care. The Clinical Practice Guidelines for hepatocellular carcinoma, first published in 2005 and most recently published in 2017 from the JSH, include recommendations for various components of treatment and is considered a reference for standards of care. Therefore, some of these guidelines’ recommendations may be candidates for process-related QIs.

The NCD, a nationwide registry of surgical procedures performed, was established in 2010 by ten academic societies, including the JSS, JSGS, and JSHBPS, that were affiliated with the board-certified surgeon (BCS) system. More than 95% of surgeries performed in Japan are now registered with the NDC, enabling evaluation of risk-adjusted surgical outcomes of nine major surgical procedures, including hepatectomy.

This study aimed to use Donabedian’s model to evaluate the quality of healthcare received by patients undergoing hepatectomy in Japan. To this end, a web-based questionnaire survey was administered to the departments registered with the NCD. QIs, including affiliations with various academic societies, number of board-certified doctors in each institute, and adherence to established clinical guidelines, were evaluated using risk-adjusted odds ratios (AOR) for operative mortality.

2 | METHODS

2.1 | Questionnaire survey

This project was approved by the Ethics Committee of Fukushima Medical University (No. 1057). An online questionnaire was installed in the NCD registration system and all departments that registered at least one hepatectomy during the survey period (from 1 October 2014 and 31 January 2015) were asked by email to complete this questionnaire. The QIs in the questionnaire related to the treatment of hepatocellular carcinoma (HCC) were classified as structure and process and are shown in Table 1. Q1 to Q8, categorized as structure QIs, were selected on the basis of the concepts described in the Introduction. Q9 to Q14, categorized as process QIs, were selected through discussions among the members of the JSH council. These QIs were mainly drawn from the
more strongly recommended items related to diagnosis and treatment of HCC in the Clinical Practice Guidelines for HCC published in 2013. For Q9 to Q14, the respondents were asked to select one of the following three responses: first choice in principle (Group A), no institutional recommendation (Group B), and recommended by the institution but performed at the doctor’s discretion (Group C).

### 2.2 Investigation of clinical data

Analysis of AORs was performed based on the data of the patients who had undergone excision of one or more sections of Healey and Schroy, except left lateral sectionectomy (MOS), in 2013 or 2014 at the institutions that responded to the questionnaire. Patients were excluded from analysis if they refused registration, had missing data with regard to sex and mortality, or did not provide informed consent. All clinical data, including background characteristics, surgical procedure, and operative mortality of the included patients were extracted from the NCD. Associations between the QIs and operative mortality in the corresponding department were evaluated using these patients’ records. Operative mortality was defined as death within the index hospitalization period up to 90 days after surgery, as well as any death after discharge, up to 30 days after surgery. With hepatectomy, 90-day mortality is considered a fair outcome measure because it provides a more accurate indicator of the true risk of death than shorter term mortality.

### 2.3 Multivariable regression analysis

To clarify the relationships between the questionnaire responses and operative mortality, multivariable logistic regression models fitted with generalized estimating equations were used, with clustering of patients by hospital level. The following variables, which have previously been identified as favorable for constructing a risk model, were used to adjust patient-level risk factors: age category, sex, activities of daily living within the 30 days before surgery (any assistance), chronic obstructive pulmonary disease, cancer metastasis/relapse, weight loss, white blood cell count <4500/μL, platelet count <120,000/μL, serum albumin <3.5 g/dL, blood urea nitrogen <8 mg/dL, serum Na <138 mEq/L, and prothrombin time-international normalized ratio >1.25. The results are expressed as adjusted odds ratios (AORs) for operative mortality and 95% confidence intervals (CIs).

### 2.4 Statistical analysis

χ² or Fisher’s exact tests were performed to compare categorical data and their distributions as appropriate. Two-sided probability values <.05 were considered to denote statistical significance. All statistical calculations were performed using STATA 15 (STATA Corp.).

### 3 RESULTS

#### 3.1 Patient entry, questionnaire survey, and crude operative mortality

In total, 749 departments responded to the questionnaire. Among them, 592 departments registered at least one
hepatectomy in 2013 or 2014, forming the study subjects. Based on the NCD, 1255 departments registered at least one hepatectomy in 2013 or 2014, thus, 47.2% of them responded to the questionnaire. Of 15 603 patients who had undergone MOS hepatectomies in 2013 or 2014 that were registered with the NCD, 8601 patients (55.1%) that had been registered with the NCD by departments responding to the questionnaire and had agreed to participate in this study were included in this analysis. Relevant patient characteristics and their relationships with crude operative mortality rates are shown in Table 2. Most of the previously identified risk model variables showed statistically significant relationships with crude operative mortality rates.

The distribution of responses for each QI and the relationship between each QI and crude operative mortality rates are shown in Table 3. Responses to the questionnaire were received from 476 (56.2%) of the 847 institutions certified by the JSGS as of 2014, 167 (79.1%) of the 211 institutions certified by the JSHBPS as of 2014, and 212 (55.6%) of the 381 institutions certified by the JSH as of 2014. Total number of BCS by JSGS was 2478 in the 749 institutions responding to the questionnaire; that of BCS and board-certified instructors by JSHBPS was 450; that of board-certified hepatologists by JSH was 676; and that of board-certified oncologists by JBCT was 2470. Institutions that were certified by the JSGS (Q2), JSHBPS (Q3), or JSH (Q4) showed significantly lower crude operative mortality rates. The number of doctors board-certified by the JSGS (Q5), JSHBPS (Q6), or JSH (Q7), and the number of board-certified general clinical oncologists (Q8) affiliated with an institution all affected crude mortality rates.

Of the 592 departments that responded to the questionnaire, 472 (79.7%) gave the Group A response (“performed in principle”) for tumor markers (Q9), as did 504 (85.1%) for dynamic computed tomography (CT) or magnetic resonance imaging (MRI) (Q10), and 180 (30.4%) for contrast-enhanced ultrasonography (Q11). For hepatic pedicle clamping (Q12), transcatheter chemoembolization/transcatheter embolization (TACE/TAE) (Q13), and radiofrequency ablation (RFA) (Q14), 420 (70.9%), 331 (55.9%), and 260 (43.9%), respectively, responded “performed in principle” (Group A). For these questionnaire items, there were no significant differences in crude mortality rates between Group A, B, and C.

3.2 | Relationships between the board certification systems and AORs

The results after risk adjustment using the factors listed in the Methods are shown in Figure 1. The numbers of the patients who showed operative death in the departments not accredited by or related to JSS was only 1 (0.4%). Therefore, Q1 did not proceed to multivariable analysis. For Q2 and Q3, AORs were significantly lower for departments that were certified as training sites for academic surgical societies (JSGS; $P < .03$, JSHBPS; $P < .001$) than for those that were not certified. For Q4, AORs were also significantly lower for departments of board-certified training institutions by JSH than for those that were not certified ($P = .001$). The impact of the number of BCSs or board-certified doctors affiliated with each department was evaluated by Q5-Q8. AORs tended to be lower for institutions with more JSGS-BCSs (Q5) or JHS board-certified doctors (Q7); however, these differences were not statistically significant. AORs tended to be lower for institutions with more JSHBPS-board-certified expert surgeons or instructors, and were significantly lower for institutions with three or more JSHBPS-certified experts or instructors than for those with none. Institutions with three or more, two, one, and no JSHBPS-certified experts or instructors performed a mean of 28, 15, and three hepatectomies per year, respectively. The number of general clinical JBCT-certified oncologists affiliated with an institution (Q8) did not have a significant impact on AORs.

3.3 | Relationships between process QIs and AORs

Relationships between the rates of implementation of the addressed QIs and AORs are shown in Figure 2. Most departments (79.7%) responded “the first choice” (Group A) for measuring two or more tumor markers (Q9). The majority of responding departments (85.1%) gave Group A responses to Q10, which assesses performance of dynamic CT or MRI. Hepatic pedicle clamping during liver transection (Q12) was reported as the first choice (Group A) by majority (70.9%) of respondents. There were no significant differences in AORs between the groups for any of the above-listed QIs.

4 | DISCUSSION

This study aimed to evaluate the impact of the board certification system and adherence to established clinical practice guidelines in Japan on the quality of healthcare in the field of liver surgery by using structure QIs and process QIs, AORs for operative mortality being the primary endpoint. Board certification of institutions by the JSGS, JSHBPS, and JSH significantly decreased AORs for operative mortality after hepatectomy, which may enhance the importance of multidisciplinary diagnosis and treatment of HCC. The number of BCSs and board-certified physicians affiliated with an institution tended to be associated with lower AORs, as was affiliation with an institution of three or more JSHBPS-certified expert surgeons or instructors. Responses to a web-based questionnaire survey by departments registered with the NCD
showed that the majority of the six process QIs were highly performed. However, implementation of these items was not associated with significant differences in post-hepatectomy AORs. These findings will likely facilitate improvements in the quality of surgical care in Japan.

Although institutional board certification by the JSGS or JSHBPS was associated with significantly lower AORs, certification by the JSS was not. Board certification of a surgeon by the JSS, JSGS, and JSHBPS occur stepwise in that order; additionally, board certification of an institution by each of these societies requires the presence of BCSs. Moreover, board certification by the JSS, JSGS, and JSHBPS requires more than 150 surgical procedures per year, more than 200 procedures including 40 major procedures (surgery for esophageal cancer, distal gastrectomy, total gastrectomy, surgery for colon cancer, surgery for rectal cancer, surgery for ileus, partial hepatectomy, two or more segmentectomies of the liver, or pancreaticoduodenectomy) per year on

| Variables                        | Mortality (n = 251) | Alive (n = 8350) | P  |
|----------------------------------|--------------------|-----------------|----|
| Age                              |                    |                 |    |
| -59                              | 17                 | 1616            | 19.4% <.001 |
| 60-64                            | 24                 | 1182            | 14.2% |
| 65-69                            | 44                 | 1482            | 17.7% |
| 70-74                            | 61                 | 1763            | 21.1% |
| 75-79                            | 59                 | 1490            | 17.8% |
| 80-                              | 46                 | 817             | 9.8%  |
| Male                             | 201                | 5820            | 69.7% <.001 |
| Emergent surgery                 | 5                  | 63              | 0.8%  .048* |
| ADL within 30 days before surgery (any assistance) | 23                 | 187             | 2.2%  <.001 |
| COPD                             | 14                 | 230             | 2.8%  .008  |
| Preoperative pneumonia           | 55                 | 109             | 1.3%  <.001  |
| Ascites (any)                    | 17                 | 176             | 2.1%  <.001  |
| ASA class 3, 4, 5                | 83                 | 994             | 11.9% <.001  |
| Intrahepatic cholangiocarcinoma  | 27                 | 963             | 11.5% .704  |
| Hilar bile duct carcinoma        | 7                  | 40              | 0.5%  <.001* |
| Gallbladder cancer               | 16                 | 146             | 1.7%  <.001  |
| Hemoglobin <10g/dL               | 43                 | 583             | 7.0%  <.001  |
| Platelet <120 000/μL             | 47                 | 837             | 10.0% <.001  |
| Platelet <80 000/μL              | 14                 | 154             | 1.8%  <.001  |
| Albumin <3.5 g/dL                | 108                | 1277            | 15.3% <.001  |
| Albumin <3.0 g/dL                | 47                 | 382             | 4.6%  <.001  |
| AST >40 U/L                      | 124                | 2284            | 27.4% <.001  |
| PT-INR >1.1                      | 58                 | 1050            | 12.6% <.001  |
| Hepatocetomy with S1             | 70                 | 1334            | 16.0% <.001  |
| Hepatocetomy with S7             | 153                | 3974            | 47.6% <.001  |
| Hepatocetomy with S8             | 162                | 4121            | 49.4% <.001  |
| Hepatocetomy with revascularization | 13               | 122             | 1.5%  <.001  |
| left tri-sectionectomy with S1 resection | 7                  | 84              | 1.0%  .017*  |

Abbreviations: ADL, activity of daily living; ASA, American Society of Anesthesiologists; AST, aspartate aminotransferase; BUN, blood urea nitrogen; COPD, chronic obstructive pulmonary disorder; PT-INR, prothrombin time international normalized ratio.

*Fisher’s exact test.
| Questionnaire item                                      | No. of departments | Operative mortality (n = 251) | Alive (n = 8350) | Total | Mortality rate |
|--------------------------------------------------------|--------------------|-------------------------------|------------------|-------|---------------|
| Q1 Institution accredited by or related to JSS         |                    |                               |                  |       | P = .185*     |
| No                                                     | 11                 | 1                             | 36               | 37    | 0.4%          |
| Accredited                                            | 503                | 234                           | 7974             | 8208  | 95.4%         |
| Relater                                                | 78                 | 16                            | 340              | 356   | 4.1%          |
| Q2 Institution certified by JSGS                       |                    |                               |                  |       | P = .030      |
| Yes                                                    | 476                | 230                           | 7912             | 8142  | 94.7%         |
| No                                                     | 116                | 21                            | 438              | 459   | 5.3%          |
| Q3 Board-certified training institution by JSHBPS      |                    |                               |                  |       | P < .001      |
| Yes                                                    | 167                | 131                           | 5572             | 5703  | 66.3%         |
| No                                                     | 425                | 120                           | 2778             | 2898  | 33.7%         |
| Q4 Institution certified by JSH                        |                    |                               |                  |       | P < .001      |
| Yes                                                    | 212                | 134                           | 5433             | 5567  | 64.7%         |
| No                                                     | 380                | 117                           | 2917             | 3034  | 35.3%         |
| Q5 No. of BCS by JSGS                                  |                    |                               |                  |       | P < .001*     |
| 0                                                      | 20                 | 3                             | 87               | 90    | 1.0%          |
| 1                                                      | 82                 | 18                            | 345              | 363   | 4.2%          |
| 2-3                                                    | 250                | 90                            | 2062             | 2152  | 25.0%         |
| 4-                                                     | 240                | 140                           | 5856             | 5996  | 69.7%         |
| Q6 No. of board-certified experts or instructors by JSHBPS |                   |                               |                  |       | P < .001      |
| 0                                                      | 332                | 68                            | 1816             | 1884  | 21.9%         |
| 1                                                      | 160                | 91                            | 2474             | 2565  | 29.8%         |
| 2                                                      | 56                 | 48                            | 1638             | 1686  | 19.6%         |
| 3-                                                     | 44                 | 44                            | 2242             | 2466  | 28.7%         |
| Q7 No. of hepatologists certified by JSH               |                    |                               |                  |       | P = .009      |
| 0                                                      | 290                | 70                            | 2509             | 2579  | 30.0%         |
| 1                                                      | 150                | 87                            | 2146             | 2233  | 26.0%         |
| 2                                                      | 74                 | 33                            | 1091             | 1124  | 13.1%         |
| 3-                                                     | 78                 | 61                            | 2604             | 2665  | 31.0%         |
| Q8 No. of board-certified oncologists                  |                    |                               |                  |       | P = .021*     |
| 0                                                      | 52                 | 7                             | 301              | 308   | 3.6%          |

(Continues)
| Questionnaire item | No. of departments | Operative mortality (n = 251) | Alive (n = 8350) | Total | No. of patients | % | No. of patients | % | No. of patients | % | Mortality rate |
|--------------------|-------------------|-----------------------------|-----------------|-------|----------------|---|----------------|---|----------------|---|--------------|
| 1                  | 106               | 21                          | 989             | 1010 |               |    | 8350           |    | 4637           |    | 11.7%        | 2.1%        |
| 2-3                | 222               | 99                          | 2547            | 2646 |               |    | 8350           |    | 4637           |    | 30.8%        | 3.7%        |
| 4-                 | 212               | 124                         | 4513            | 4637 |               |    | 8350           |    | 4637           |    | 53.9%        | 2.7%        |
| **Q9** Two or more tumor markers |                  |                             |                 |       |               |    |                |    |                |    |             |             |
| First choice in principle | 472               | 224                         | 7258            | 7482 |               |    | 86.9%          |    | 3.0%          |    |             |             |
| No institutional recommendation | 15               | 5                           | 167             | 172  |               |    | 2.0%           |    | 2.0%          |    |             |             |
| Recommended by institution but doctor’s discretion | 105              | 22                          | 925             | 947  |               |    | 11.0%          |    | 2.3%          |    |             |             |
| **Q10** Dynamic CT or MRI |                  |                             |                 |       |               |    |                |    |                |    |             |             |
| First choice in principle | 504               | 227                         | 7580            | 7807 |               |    | 90.8%          |    | 2.9%          |    |             |             |
| No institutional recommendation | 12              | 8                           | 168             | 176  |               |    | 2.0%           |    | 2.0%          |    |             |             |
| Recommended by institution but doctor’s discretion | 76              | 16                          | 602             | 618  |               |    | 7.2%           |    | 2.6%          |    |             |             |
| **Q11** Contrast-enhanced ultrasonography |                  |                             |                 |       |               |    |                |    |                |    |             |             |
| First choice in principle | 180               | 76                          | 2884            | 2960 |               |    | 34.5%          |    | 34.4%         |    |             |             |
| No institutional recommendation | 202              | 81                          | 2700            | 2781 |               |    | 32.3%          |    | 32.3%         |    |             |             |
| Recommended by institution but doctor’s discretion | 210              | 94                          | 2766            | 2860 |               |    | 33.1%          |    | 33.3%         |    |             |             |
| **Q12** Hepatic pedicle clamp |                  |                             |                 |       |               |    |                |    |                |    |             |             |
| First choice in principle | 420               | 195                         | 6541            | 6736 |               |    | 78.3%          |    | 78.3%         |    |             |             |
| No institutional recommendation | 43               | 16                          | 587             | 603  |               |    | 7.0%           |    | 7.0%          |    |             |             |
| Recommended by institution but doctor’s discretion | 129              | 40                          | 1222            | 1262 |               |    | 14.6%          |    | 14.7%         |    |             |             |
| **Q13** TACE/TAE |                  |                             |                 |       |               |    |                |    |                |    |             |             |
| First choice in principle | 331               | 168                         | 5990            | 6158 |               |    | 71.7%          |    | 71.6%         |    |             |             |
| No institutional recommendation | 61               | 20                          | 573             | 593  |               |    | 6.9%           |    | 6.9%          |    |             |             |
| Recommended by institution but doctor’s discretion | 200              | 63                          | 1787            | 1850 |               |    | 21.4%          |    | 21.5%         |    |             |             |
| **Q14** RFA |                  |                             |                 |       |               |    |                |    |                |    |             |             |
| First choice in principle | 260               | 130                         | 4166            | 4296 |               |    | 49.9%          |    | 49.9%         |    |             |             |
| No institutional recommendation | 103              | 36                          | 1220            | 1256 |               |    | 14.6%          |    | 14.6%         |    |             |             |
| Recommended by institution but doctor’s discretion | 229              | 85                          | 2964            | 2984 |               |    | 35.5%          |    | 35.5%         |    |             |             |

Abbreviations: JSGS, Japanese Society of Gastroenterological Society; JSH, Japan Society of Hepatology; JSHBPS, Japanese Society of Hepato-Biliary-Pancreatic Surgery; JSS, Japan Surgical Society; QI, Quality indicator; RFA, radiofrequency ablation; TACE, transcatheter arterial chemoembolization; TAE, transcatheter arterial embolization.

*Fisher’s exact test.
average, and 50 (Level A) or 30 (Level B) high-level HBP surgical procedures per year, respectively. In addition, board certification of experts by JSHBPS required video review of candidates’ operation. The present findings indicate that certification by the subspeciality (JSGS) and super-subspeciality (JSHBPS) societies contributes to improving the quality of hepatectomy in Japan.

In this study, the more numerous the JSGS-certified surgeons affiliated with an institution, the lower AORs tended to be; however, this difference was not statistically different. Konno et al have demonstrated that affiliation of four or more JSGS-certified surgeons with an institution is associated with a significantly lower operative mortality after hepatectomy.\(^{20}\) Their results differ somewhat from ours, possibly because of differences in the study cohorts (whole hepatectomies in 2011 and 2012 vs. MOS hepatectomies at questionnaire-responding institutions in 2013 and 2014). However, the tendencies were similar in the two studies. Additionally, in the present study the larger the number of JSHBPS-certified experts or instructors affiliated with an institution, the lower were the post-hepatectomy AORs. It is reasonable to assume that a high-risk surgical procedure like hepatectomy is better performed by a specialized team rather than by a single highly skilled surgeon. Indeed, affiliation of a greater number of JSHBPS-certified experts or instructors with an institution was associated with a greater number of hepatectomies performed in the institution per years. Given that it has been reported that the number of hepatectomies that one surgeon or one surgical team performs is reflected in their short-term results,\(^{21,22}\) whether institutional volume affects short-term results requires further evaluation. In the present study, we found that institutional board certification by the JHS had a significant impact on AORs and that the number of JSH-certified hepatologists affiliated with an institution tended to be associated with more favorable AORs; however, this difference was not statistically significant. These results highlight the importance of multidisciplinary treatment for HCC, suggesting that it could be a benchmark for institutional quality.

The six process QIs were based on the recommendations with higher grades in the Japanese Clinical Practice Guidelines published in 2013.\(^ {15}\) To our knowledge, the present study is the first to assess the clinical impact of implementing clinical guidelines in the field of hepatectomy. Two or more tumor markers were measured in most responding institutions; however, contrast-enhanced ultrasonography was less commonly performed (group A: 30.4%). Hepatic pedicle clamping to decrease bleeding during hepatectomy was implemented in most institutions. None of these items was significantly associated with lower AORs, which is in contrast with the findings for esophagectomy by Toh et al,\(^ {23}\) hemicolecetomy by Kobayashi et al,\(^ {24}\) and pancreaticoduodenectomy by Mizuma et al.\(^ {25}\) In all three of these studies, lower post-surgery AORs were significantly associated with implementation of some of the relevant clinical practice guidelines. Most such previous reports focused on surgical decisions and follow-up treatment. In contrast, three of the six process QIs selected in the present study were related to procedures for diagnosing HCC, two to non-surgical treatment,
namely TACE and RFA, only one being directly related to the surgical procedure. This was because it has been difficult to establish strong consensus concerning surgical procedures, resulting in a paucity of strong recommendations regarding them in the clinical practice guidelines for liver cancer. All of the above-mentioned factors may contribute to explaining the differences in results. Besides the present analysis, a study addressing the relationship between board certification and adherence to clinical guidelines would be worth conducting.

Higashi et al. drew on the Nationwide Survey of Primary Liver Cancer in Japan to investigate implementation rates of six process QIs,\textsuperscript{26} two of these six QIs, namely, tumor markers and TACE, being similar to those selected for the present study. In that study, all six QIs were implemented relatively frequently (between 64.4\% and 91.1\%). It was not possible to directly compare their results with ours for the following reasons. First, Higashi et al. used clinical data registered in a nationwide survey to calculate the implementation rates of each QI, whereas we used data from responses to our questionnaire to calculate the proportion of institutions implementing the selected QIs. Second, they used clinical data from between 2002 and 2003, whereas our questionnaire

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig2.png}
\caption{Relationship between the rate of implementation of each process-related quality indicator and the risk-adjusted odds ratio for operative mortality. The results show point estimates of odds ratio and 95\% confidence intervals. Q9: Measurement of two or more tumor markers. Q10: Performance of dynamic CT/MRI. Q11: Performance of contrast-enhanced ultrasonography. Q12: Hepatic pedicle clamping during liver transection. Q13: TACE/TAE for advanced HCC in patients with level A or B liver damage. Q14: Performance of RFA as a primary choice for local therapy for HCC.}
\end{figure}
The limitations of this study are similar to those of previously studies. First, we cannot exclude the possibility of bias in the responses to the questionnaire survey. The respondents were all registered with the NCD as its users but were not necessarily representative of their departments. Moreover, it was possible that surgeons instead of gastroenterologists answered the QIs regarding contrast-enhanced ultrasonography and RFA, which were usually performed by gastroenterologists. Thus, their responses do not necessarily reflect their departments' policies. Second, fewer than half of the invited institutions participated in the survey. Rates of implementation of the selected QIs or the mortality of hepatectomy may have differed between responding and non-responding institutions. Third, although the QIs were carefully selected by discussions between expert members of the JSH, the possibility that the selected QIs are not the most optimal for assessing the quality of liver surgery requires further discussion, especially considering they were selected from the limited number of recommendations in the clinical practice guidelines. Furthermore, process QIs were selected from clinical practice guidelines for HCC, which were not aimed only for liver surgery. However, process QIs based on clinical guidelines were assessed in order to evaluate the quality of health care, not limited to treatment of HCC, for each institution.

In conclusion, institutional board certification by the JSGS, JSHBPS, and JSH, and affiliation of three or more JSHBPS-certified experts or instructors with an institution was associated with significantly lower AORs after hepatectomy. Use of appropriate QIs may improve the outcomes after hepatectomy.

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CONFLICT OF INTEREST

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