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ORIGINAL ARTICLE

D3 lymph node dissection in colon cancer patients aged 90 years and over: Is it justified? A multi-institutional retrospective study

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Abstract

Aim: The oncological benefit of D3 lymph node dissection (D3 LND) for colon cancer in patients aged ≥90 years remains unclear. This study aimed to evaluate the impact of D3 LND on outcomes in this specific, vulnerable population.

Method: This retrospective cohort study evaluated 166 patients aged ≥90 years with pathological Stages II–III colon cancer undergoing non-D3 or D3 LND from a multicentre database (2011–2022). Postoperative complications, overall survival and cancer-specific survival were compared between LND groups using propensity score-weighted analyses.

Results: D3 LND group had significantly more females and laparoscopic procedures. Operation time was longer, and blood loss was lower in the D3 LND group. Postoperative complications and severe complications were significantly fewer, and postoperative hospital stay was shorter in the D3 LND group. The number of harvested lymph nodes and distal margin was significantly higher in the D3 group. While unadjusted analysis showed better overall survival with D3 LND ($p < 0.001$), adjusted cancer-specific survival showed no significant difference ($p = 0.10$). Adjusted mortality risk was significantly higher in the non-D3 group ($p = 0.001$).

Conclusion: In nonagenarian colon cancer patients, D3 LND is safe and feasible without increasing complications, but lacks survival benefit. Careful consideration is warranted, and high-quality D2 LND must be consistently ensured when limited surgery is chosen.

KEYWORDS
colon cancer, lymph node dissection, nonagenarian, postoperative complication, survival benefit

INTRODUCTION

Colorectal cancer (CRC) remains a significant global health challenge, with increasing incidence among older populations [1]. Surgical resection with lymph node dissection is crucial for curative treatment of colon cancer. Complete mesocolic excision (CME) with D3 lymph node dissection (LND) aims to remove the tumour along with its surrounding mesentery and regional lymph nodes up to the feeding

Setouchi Colorectal Neoplasm Registration study group collaborators are listed in Appendix A.

vessels, demonstrating improved oncological outcomes compared to conventional colectomy [2]. However, recent evidence suggests that CME for right-sided colon cancer may have limited therapeutic benefit [3, 4]. These findings primarily derive from studies of younger patients, and their applicability to patients aged 90 years and older remains uncertain. The advantages and risks of extensive LND in this population, which experiences higher surgical morbidity and mortality, are not well established. The potential benefits of radical surgery in extremely older patients must be balanced against their elevated risk of complications due to comorbidities and frailty [5]. This multi-institutional retrospective study evaluated the impact of D3 LND on short-term and long-term outcomes in 166 colon cancer patients aged 90 years and older, aiming to determine whether D3 LND confers meaningful benefit in this population.

What does this paper add to the literature?

This study is the first multi-institutional analysis evaluating D3 lymph node dissection in colon cancer patients aged ≥90 years. It demonstrates that D3 is safe and feasible without increasing complications, yet confers no cancer-specific survival advantage, thereby informing surgical decision-making and emphasizing the importance of high-quality D2 dissection.

METHODS

The ethics committee of Okayama University Hospital approved this retrospective study (approval number 2112-036) and all participating hospitals approved this study as exempt human subject research. Study data were collected and managed using REDCap electronic data capture tools hosted at Okayama University Hospital. REDCap is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for data integration and interoperability with external sources [6, 7].

Data collection

This retrospective, cohort study used data from the database for the Setouchi Colorectal Neoplasm Registration study, which collected information on patients aged 90 years or older from 15 Okayama University-affiliated hospitals between January 2011 and December 2022. A total of 403 cases of colorectal cancer in the oldest patients were identified. The inclusion criteria were patients with colon cancer undergoing non-D3 or D3 LND for pathological Stage II or III cancer, and exclusion criteria included rectal cancer, emergency surgery and cases with missing data. Screening results showed that 166 Stage II–III patients were included in the study sample (Figure 1). The definition of colon cancer stage was based on the Japanese Classification of Colorectal, Appendiceal and Anal Carcinoma [8].

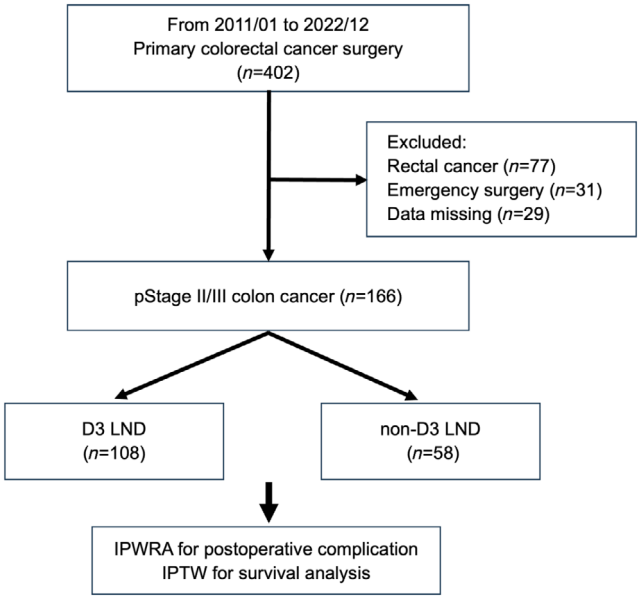

FIGURE 1 Flowchart of patient selection. IPTW, inverse probability of treatment weighting; IPWRA, inverse probability-weighted regression adjustment; pStage, pathological Stage.

Definition of lymph node stations and D3 LND

The definition of lymph node (LN) stations was based on the Japanese Classification of Colorectal, Appendiceal and Anal Carcinoma. LN stations are defined as follows: Intermediate LNs are located along the ileocaecal, right colonic, middle colonic, left colonic, sigmoid and inferior mesenteric arteries, between the origin of the artery and the terminal colonic artery. Main LNs are located at the origin of the ileocaecal, right colonic, middle colonic and inferior mesenteric arteries (Figures S1 and S2). D3 dissection was defined as resection of the para-intestinal, intermediate and main lymph nodes [8]. The specific range of regional lymph nodes is individually defined according to the anatomical relationship between the location of the tumour and its main feeding artery/arteries (Figure S3).

Regarding the classification of lymph node dissection, the extent of lymphadenectomy was categorized retrospectively based on operative records. Since no treatment guidelines specific to older patients are currently available, clinical staging was performed using imaging modalities such as endoscopy and CT, and treatment planning was based on the Japanese Society for Cancer of the Colon and Rectum (JSCCR) 2019 guidelines for the treatment of colorectal cancer, including recommendations on the extent of lymph node dissection [9]. Ultimately, each institution

conducted a preoperative conference to determine the surgical approach and the extent of lymphadenectomy. Postoperative follow-up was performed according to the practices of individual centres and the JSCCR 2019 guidelines [9]. Clinicopathological variables were compared between the non-D3 and D3 LND groups. The primary endpoints were postoperative complication rates, overall survival and cancer-specific survival, defined as the interval from surgery to death from any cause and to death attributable to cancer, respectively.

Statistical analysis

First, descriptive statistics were calculated, with continuous variables presented as median (range) and categorical variables shown as frequencies (percentages). Categorical variables were compared between the non-D3 and D3 lymph node dissection (LND) groups using Fisher's exact or chi-square tests, while continuous variables were compared using the Mann–Whitney *U* test.

For postoperative complications, differences between non-D3 and D3 LND groups were calculated as risk ratios and their 95% confidence intervals (CIs) using modified Poisson regression. 95% Cis were calculated using the Huber-White sandwich estimator. Inverse probability-weighted regression adjustment (IPWRA) [10], which is doubly robust, was employed to adjust for confounding factors. In the IPWRA treatment model (i.e. inverse probability weighting), propensity scores were calculated using a logistic regression model, with age, gender, tumour location, ASA classification, pStage and surgical approach as explanatory variables and LND (D3 or non-D3) as the response variable. The propensity scores were utilized to compute the stabilized weights in the IPWRA method, applying the following formula:

In D3 LND group,

$$\text{weight} = \frac{\Pr(\text{D3 LND})}{\text{Propemsity Score}}$$

In non-D3 LND group,

$$\text{weight} = \frac{\Pr(\text{non D3 LND})}{1 - \text{Propemsity Score}}$$

In the IPWRA outcome model (i.e. regression adjustment), a modified Poisson regression was performed with the same variables to calculate the propensity score and estimate the risk of postoperative complications.

For survival time analysis, the inverse probability of treatment weighting (IPTW) method was performed to adjust for confounding. In IPTW, propensity scores were calculated using a logistic regression model, with age, gender, tumour location, ASA classification, pStage, postoperative complication and surgical approach as explanatory variables. Overall survival (OS) was calculated using the Kaplan–Meier method, and the two groups were compared using the log-rank test. To evaluate the cancer-specific survival (CSS), competing risk analysis using the cumulative incident function was performed, and the two groups were compared using the Pepe-Mori test.

All statistical analyses were conducted using Stata/MP (version 18.0, Stata Corp, College Station, TX, USA). A $p < 0.05$ was considered statistically significant. Because this study has an exploratory component, a multiplicity of tests was not considered [11].

RESULTS

Table 1 shows the clinical characteristics, surgical outcomes and pathological outcomes. Among 180 cases of D3 LND and 58 cases of non-D3 LND, the D3 LND group included 79 females (73.1%) and 29 males (26.9%), while the non-D3 LND group had 32 females (55.2%) and 26 males (44.8%), showing significantly more females in the D3 LND group ($p = 0.02$). The BMI was 20.2 kg/m^2 in the D3 LND group and 20.1 kg/m^2 in the non-D3 LND group. Cases with ASA classification ≥3 numbered 61 (56.5%) in the D3 LND group and 41 (70.7%) in the non-D3 LND group. Regarding tumour location, right-sided colon (from caecum to transverse colon) accounted for 84 cases (77.7%) in the D3 group and 40 cases (68.9%) in the non-D3 group. The surgical approach in the D3 group consisted of 40 open surgeries (37.0%) and 68 laparoscopic surgeries (63.0%), while the non-D3 group had 40 open surgeries (68.9%) and 18 laparoscopic surgeries (31.1%), showing significantly more laparoscopic procedures in the D3 group ($p < 0.01$).

Regarding surgical outcomes, operation time was significantly longer in D3 LND at 205 min compared to 179 min in non-D3 LND ($p = 0.03$). Blood loss was significantly lower in D3 LND at 20 mL compared to 50 mL in non-D3 LND ($p = 0.04$). Postoperative complications of all Clavien-Dindo grades occurred in 29 cases (26.9%) in the D3 group and 25 cases (43.1%) in the non-D3 group, showing significantly fewer complications in the D3 group ($p = 0.03$). Severe complications of Clavien-Dindo grade III or higher were observed in 1 case (0.9%) in the D3 group and 4 cases (7.0%) in the non-D3 group, significantly lower in the D3 group ($p = 0.03$). There were no 30-day mortalities in either group. Postoperative hospital stay was significantly longer in the non-D3 group at 17 days compared to 13 days in the D3 group ($p < 0.01$). One reoperation was required in the non-D3 group due to wound dehiscence.

Regarding pathological outcomes, tumour size was 55 mm in both groups with no significant difference. The number of harvested lymph nodes was significantly higher in the D3 group at 19 nodes compared to 12 nodes in the non-D3 group ($p < 0.01$). The distal margin was significantly longer in the D3 group at 100 mm compared to 70 mm in the non-D3 group ($p < 0.01$). The D3 group included 64 cases (59.3%) of pStage II and 44 cases (40.7%) of pStage III, while the non-D3 group had 39 cases (67.2%) of pStage II and 19 cases (32.8%) of pStage III ($p = 0.31$).

To improve covariate balance between the D3 LND and non-D3 LND groups, IPTW and IPWRA methods were applied for weighting. Standardized mean differences (SMDs) and variance ratios (VRs) were calculated to assess covariate balance, with an absolute SMD

TABLE 1 Baseline patient characteristics, surgical outcomes and pathological outcomes.

	All	D3	Non-D3	
	N = 166	*N* = 108	*N* = 58	*p*-Value
Age, years, median (IQR)	92 (91–93)	92 (91–93)	92 (91–93)	0.70
Gender, *n* (%)				
Male	55 (33.1)	29 (26.9)	26 (44.8)	**0.02**
Female	111 (66.9)	79 (73.1)	32 (55.2)	
BMI, kg/m^2, median (IQR)	20.2 (18.2–22.0)	20.2 (18.1–22.2)	20.1 (18.6–21.9)	0.72
ASA classification, *n* (%)				
2	63 (38.0)	46 (42.6)	17 (29.3)	0.08
3	101 (60.8)	60 (55.6)	41 (70.7)	
4	1 (0.6)	1 (0.9)	0 (0)	
Unknown	1 (0.6)	1 (0.9)	0 (0)	
Tumour location, *n* (%)				
Right	124 (74.8)	84 (77.7)	40 (68.9)	0.21
Cecum	26 (15.7)	21 (19.4)	5 (8.6)	
Ascending colon	75 (45.2)	54 (50.0)	21 (36.2)	
Transverse colon	23 (13.9)	9 (8.3)	14 (24.1)	
Left	42 (25.2)	24 (22.3)	18 (31.1)	
Descending colon	6 (3.6)	2 (1.9)	4 (7.0)	
Sigmoid colon	36 (21.6)	22 (20.4)	14 (24.1)	
Surgical approach, *n* (%)				
Open	80 (48.2)	40 (37.0)	40 (68.9)	**<0.01**
Laparoscopy	86 (51.8)	68 (63.0)	18 (31.1)	
Surgical outcome				
Operation time, min, median (IQR)	195 (143–246)	205 (149–252)	179 (120–225)	**0.03**
Blood loss, mL, median (IQR)	30 (10–100)	20 (10–90)	50 (10–159)	**0.04**
Postoperative complications				
C-D grade I–V, *n* (%)	54 (32.5)	29 (26.9)	25 (43.1)	**0.03**
C-D grade ≧III, *n* (%)	5 (3.0)	1 (0.9)	4 (7.0)	**0.03**
30-day mortality, *n* (%)	0 (0)	0 (0)	0 (0)	
Length of stay, days, median (IQR)	14 (11–20)	13 (11–18)	17 (13–26)	**<0.01**
Reoperation, *n* (%)	0 (0)	0 (0)	1 (1.7)	
Pathological outcome				
Tumour size, mm, median (IQR)	55 (40–70)	55 (42–70)	55 (38–70)	0.85
Harvested lymph node, median (IQR)	17 (11–25)	19 (13–27)	12 (7–20)	**<0.01**
Proximal margin, mm, median (IQR)	83 (60–120)	90 (65–130)	80 (50–113)	0.18
Distal margin, mm, median (IQR)	90 (60–110)	100 (70–115)	70 (40–100)	**<0.01**
pStage, *n* (%)				
II	103 (62.0)	64 (59.3)	39 (67.2)	0.31
III	63 (38.0)	44 (40.7)	19 (32.8)	

Abbreviations: ASA, American Society of Anaesthesiologists; BMI, body mass index; C-D, Clavien-Dindo classification; IQR, interquartile range; pStage, pathological Stage.

<0.1 and a VR between 0.8 and 1.25 indicating adequate balance, according to Jackson et al. [12]. Table 2 shows that all covariates met these criteria, demonstrating improved balance between D3 LND and non-D3 LND groups after weighting. The unadjusted risk ratio for postoperative complications in non-D3 LND compared to D3 LND was 1.61 (95% CI, 1.04–2.47) ($p = 0.031$). After IPWRA adjustment, the risk ratio was 1.43 (95% CI, 0.87–2.35) ($p = 0.164$), showing no significant difference (Table 3).

Figure 2A shows the Kaplan–Meier curves for overall survival in D3 LND and non-D3 LND cases. The D3 group showed significantly

TABLE 2 Clinical characteristics of patients after propensity matching using IPTW or IPWRA method.

	Unweighted				Weighted for OS				Weighted for postoperative complication			
	D3	Non-D3	Balance		D3	Non-D3	Balance		D3	Non-D3	Balance	
	N = 108	*N* = 58	SMD	VR	106 (62.7)	63 (37.3)	SMD	VR	106 (63.4)	61 (36.6)	SMD	VR
Age, years, median (IQR)	92 (91–93)	92 (91–93)	0.04	0.97	92 (91–93)	92 (91–93)	−0.09	0.82	92 (91–93)	92 (91–93)	−0.04	0.79
Gender, *n* (%)												
Female	79 (73.1)	32 (55.2)	0.38	1.27	71.95 (67.9)	45.21 (71.9)	−0.09	0.94	72.37 (68.2)	42.53 (69.5)	−0.03	0.98
Male	29 (26.9)	26 (44.8)			33.96 (32.1)	17.70 (28.1)			33.80 (31.8)	18.64 (30.5)		
Tumour location, *n* (%)												
Left	24 (22.3)	18 (31.1)	−0.20	1.25	24.66 (23.3)	12.96 (20.6)	0.06	0.92	24.93 (23.5)	12.83 (21.0)	0.06	0.93
Right	84 (77.7)	40 (68.9)			81.25 (76.7)	49.94 (79.4)			81.24 (76.5)	48.34 (79.0)		
ASA classification, *n* (%)												
ASA 2	46 (42.6)	17 (29.3)	0.28	0.85	41.90 (39.6)	27.96 (44.4)	−0.10	1.04	41.78 (39.4)	26.54 (43.4)	−0.08	1.04
ASA 3/4	62 (57.5)	41 (70.7)			64.01 (60.4)	34.95 (55.6)			64.39 (60.6)	34.63 (56.6)		
pStage, *n* (%)												
II	64 (59.3)	39 (67.2)	−0.17	0.92	65.16 (61.5)	38.62 (61.4)	0.00	1.01	64.67 (60.9)	37.34 (61.0)	0.00	1.01
III	44 (40.7)	19 (32.8)			40.75 (38.5)	24.29 (38.6)			41.50 (39.1)	23.83 (39.0)		
Postoperative complication, *n* (%)												
No	79 (73.1)	33 (56.9)	0.34	1.26	72.16 (68.1)	44.75 (71.1)	−0.06	0.95	77.70 (73.2)	37.76 (61.7)	0.24	1.21
Yes	29 (26.9)	25 (43.1)			33.75 (31.9)	18.16 (28.9)			28.47 (26.8)	23.41 (38.3)		
Surgical approach, *n* (%)												
Open	40 (37.0)	40 (68.9)	−0.67	0.93	49.57 (46.8)	27.03 (43.0)	0.08	0.99	50.11 (47.2)	27.60 (45.1)	0.04	1.00
Laparoscopy	68 (63.0)	18 (31.1)			56.34 (53.2)	35.88 (57.0)			56.06 (52.8)	33.57 (54.9)		

Note: (1) In 'Weighted for OS', adjustments were made for gender, tumour location, ASA classification, pStage, postoperative complication and surgical approach. In 'Weighted for postoperative complication', adjustments were made for gender, tumour location, ASA classification, pStage and surgical approach. (2) In Table 2, the SMD for 'Postoperative complication' in the 'Weighted for postoperative complication' column appears to deviate from the criterion (0.24); however, 'Postoperative complication' is the outcome variable, not a covariate to be balanced between groups.

Abbreviations: ASA, American Society of Anaesthesiologists; BMI, body mass index; SD, standard deviation; SMD, standardized mean difference; VR, variance ratio; W.Sum, weighted sum.

TABLE 3 Risk ratio of postoperative complications for non-D3 LND based on lymph node dissection D3 LND.

	Risk ratio	95% confidence interval	*p*-Value
Unadjusted	1.61	1.04, 2.47	0.031
Stabilized weighing	1.43	0.87, 2.35	0.164

Note: The *E*-value for the confidence interval under stabilized weighting was 1.000.

better prognosis compared to the non-D3 group ($p < 0.001$, log-rank test). For cancer-specific survival evaluation, competing risk analysis was performed. In the adjusted model, the risk ratio for cumulative incidence in non-D3 LND compared to D3 LND was 2.21 (95% CI, 0.85–5.74) ($p = 0.103$, Pepe-Mori test), showing no significant difference (Figure 2B). Table 4 shows the hazard ratios for mortality in non-D3 LND compared to D3 LND. In the adjusted model using Cox proportional hazards model, the hazard ratio for the non-D3 group compared to the D3 group was 4.00 (95% CI, 1.76–9.09), demonstrating significantly higher mortality risk in the non-D3 group ($p = 0.001$). In the adjusted model, the 3-year survival rates were 83.3% and 43.0% for D3 and non-D3 groups, respectively, while 5-year survival was 62.4% in the D3 group (data not shown).

DISCUSSION

Our findings demonstrated that D3 lymph node dissection (LND) could be safely performed in oldest-old colon cancer patients without increasing postoperative complications compared to non-D3 dissection. Regarding prognosis in Stages II–III colon cancer patients, while D3 LND was associated with significantly better overall survival compared to non-D3 dissection, cancer-specific survival showed no significant difference, suggesting that the prognostic contribution of D3 LND may be limited. The strength of our study lies in being the first report to examine optimal lymph node dissection in colon cancer patients aged 90 years and older, utilizing IPTW and IPWRA to adjust for background factors across data collected from multiple institutions.

According to various researchers, the incidence of postoperative complications following colorectal cancer surgery ranges from 25.9% to 66.2% in older patients, higher than in younger patients [13–16]. In our study, the complication rates ranged from 28% to 47.4%, consistent with previous reports. The observation that D3 LND did not lead to increased postoperative complications compared to non-D3 dissection might be attributed to selection bias, where surgeons chose non-D3 dissection based on their assessment of patient risk. We minimized this confounding by adjusting for ASA classification through IPTW and IPWRA, ensuring comparable overall health status between groups. Additionally, while laparoscopic surgery has been reported to reduce postoperative complications in older colorectal cancer patients due to its minimally invasive nature [17], our study matched both open and laparoscopic approaches using IPTW, suggesting that the surgical approach had minimal impact.

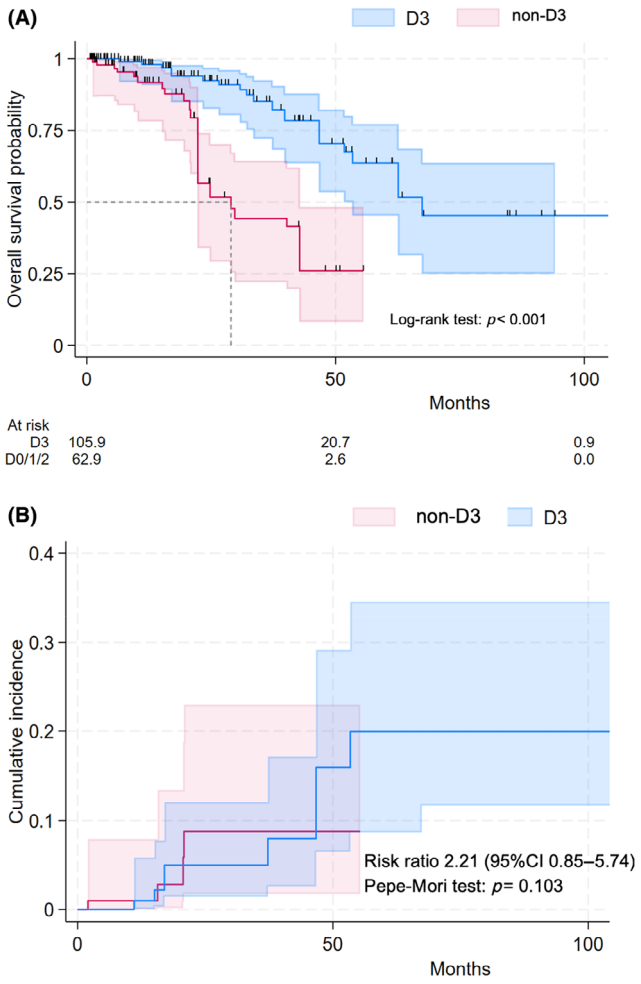

FIGURE 2 Kaplan–Meier curves of overall survival after D3 LND versus non-D3 LND following inverse probability of treatment weighting. (A) Overall survival in Stages II–III colon cancer. (B) Cumulative incidence of cancer-specific mortality in Stages II–III (log-rank test). (A) $p < 0.001$, Log-rank test; (B) $p = 0.164$, Pepe-Mori test.

Regarding prognosis, previous studies have reported 1-year, 3-year and 5-year survival rates after curative colorectal cancer resection in patients aged 90 and older at approximately 70%, 50% and 30%, respectively [13, 15, 16]. Our study demonstrated similar overall survival curves. For younger patients with Stage II–III colorectal cancer, the standard surgical treatment involves primary tumour resection with complete mesocolic excision and lymph node dissection [6], equivalent to D3 dissection. The JCOG 0404 trial, which compared laparoscopic versus open D3 surgery for Stage II–III colorectal cancer in Japan, demonstrated excellent long-term survival results with D3 dissection in Japanese patients [18]. In our study, while D3 LND showed a better prognosis in terms of overall survival compared to non-D3 dissection in oldest-old Stages II–III colorectal cancer patients, risk analysis for cancer-specific survival showed no significant difference between D3 and non-D3 LND. This suggests that non-cancer deaths likely influenced overall survival. Recent prospective clinical trials have reported that

TABLE 4 Mortality hazard ratio for non-D3 LND based on D3 LND (Cox proportional hazard model).

	Hazard ratio	95% confidence interval	*p*-Value
Unadjusted	4.26	2.09, 8.69	<0.001
Stabilized weighing	4.00	1.76, 9.09	0.001

Note: The *E*-value for the confidence interval under stabilized weighting was 2.917.

the therapeutic effect of D3 LND with CME for right-sided colon cancer is limited and should only be performed in cases with suspected mesenteric lymph node metastasis [3, 4, 19]. Furthermore, D3 LND for non-locally advanced right-sided colon cancer has not been shown to improve survival outcomes [20]. Recent reports have similarly demonstrated that D3 LND in colon cancer does not provide a significant oncological benefit [21]. In addition, the current evidence base remains limited by a lack of high-quality randomized controlled trials [22], suggesting that the benefits of D3 LND should not be overestimated. Consequently, the indication for D3 LND, particularly in right-sided colon cancer, remains controversial. Standardization of surgical techniques may help reduce heterogeneity and contribute to improved clinical outcomes. Although detailed data regarding postoperative adjuvant chemotherapy and post-recurrence treatment were not collected in our study, it is unlikely that many cases received chemotherapy, suggesting minimal impact of postoperative treatment on prognosis.

Our study has several limitations. First, this was a retrospective study. However, no previous multi-institutional cohort studies have examined treatment outcomes in colorectal cancer surgery patients aged 90 and older using IPTW and IPWRA, making our findings on optimal lymph node dissection in oldest-old colorectal cancer patients noteworthy. Second, there were institutional and surgeon-related biases. The 15 participating institutions varied in size, ranging from facilities with just a few surgeons to those with more than 15. Some institutions had colorectal surgery specialists performing operations, while others relied on general surgeons. Furthermore, cases performed by both senior surgeons and residents were included, and the exact number of surgeons involved cannot be determined from our database. In addition, ensuring surgical quality control was challenging, as the data were derived from operative records. While standardization of surgical approaches across participating institutions was challenging, our results reflect real-world data from routine surgical practice. Third, as this was an observational study, the potential influence of unmeasured confounding, such as the frailty index and adjuvant chemotherapy, cannot be excluded. However, for the mortality hazard ratio for non-D3 LND compared to D3 LND, the *E*-value [23] for the confidence interval was sufficiently large (2.917), suggesting robustness against unmeasured confounding. Fourth, information regarding geriatric functional assessment and prehabilitation intervention was lacking. While we have previously reported that multidisciplinary prehabilitation is beneficial in preventing postoperative complications in frail older colorectal cancer patients [24], this study had no unified perioperative management protocol, and details of postoperative care varied by institution.

CONCLUSION

In colon cancer surgery for nonagenarian patients, D3 LND appears to be safe and feasible, with no increase in postoperative complications across multiple institutions. Nevertheless, given the absence of a demonstrated survival advantage, the clinical value of extended lymphadenectomy in this age group warrants careful consideration. When a more limited approach is selected, it remains imperative to ensure the consistent and meticulous performance of high-quality D2 lymph node dissection.

AUTHOR CONTRIBUTIONS

Fuminori Teraishi: Conceptualization; methodology; data curation; investigation; funding acquisition; project administration; writing – original draft. **Satoe Takanaga:** Data curation; investigation; methodology; project administration. **Ryo Inada:** Data curation; writing – review and editing; investigation. **Toshiharu Mitsuhashi:** Software; writing – review and editing; methodology; formal analysis. **Toshiaki Toshima:** Writing – review and editing; data curation. **Tsuyoshi Ohtani:** Writing – review and editing; data curation. **Ryosuke Yoshida:** Data curation; writing – review and editing. **Ryohei Shoji:** Data curation; writing – review and editing. **Toshiyoshi Fujiwara:** Supervision; conceptualization; writing – review and editing. **Naoto Hori:** Data curation; writing – review and editing. **Kaoru Shigemitsu:** Writing – review and editing; data curation. **Sumiharu Yamamoto:** Writing – review and editing; data curation. **Tetsushi Kubota:** Writing – review and editing; data curation. **Yuka Okano:** Writing – review and editing; data curation. **Tetsuji Nobuhisa:** Writing – review and editing; data curation. **Fumitaka Taniguchi:** Writing – review and editing; data curation. **Wataru Ishikawa:** Data curation; writing – review and editing. **Tatsuo Matsuda:** Data curation; writing – review and editing. **Tatsuo Umeoka:** Data curation; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The all authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

All procedures performed were in accordance with the ethical standards of our institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by our Institutional Review Board (approval No. 2112-036).

INFORMED CONSENT

Informed consent was obtained from all participants included in the study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

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