SCIENTIFIC ARTICLE

Beyond resection: evaluating survival and surgical quality in colorectal cancer in a Sri Lankan cohort

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Abstract

Introduction

Colorectal cancer (CRC) is a major cause of cancer morbidity and mortality worldwide and its incidence is increasing in many Asian populations, including Sri Lanka. Evaluating surgical outcomes and prognostic determinants is essential for improving colorectal cancer management in this setting.

Methodology

A retrospective cohort study was conducted including all patients who underwent colorectal cancer resection at a tertiary referral centre in Sri Lanka between 2019 and 2023. Clinicopathological variables were extracted from histopathology reports and hospital records. Survival outcomes were determined through hospital documentation and telephone tracing where possible. Kaplan-Meier methods were used to estimate survival, and differences between groups were assessed using the log-rank test. Multivariable Cox proportional hazards regression analysis was performed to identify independent predictors of survival.

Results

A total of 570 patients underwent colorectal cancer resection during the study period. Survival status could be verified in 135 patients (23.7%), while 435 patients (76.3%) remained untraced. Among the traced patients, 47 deaths occurred during follow-up. Estimated overall survival rates were 77.8% (95% CI 70.5-85.1%) at 12 months, 71.1% (95% CI 62.9-79.3%) at 24 months, 65.5% (95% CI 56.4-74.6%) at 36 months, and 59.9% (95% CI 49.8-70.0%) at 60 months. Patients with lymph node yield ≥12 nodes demonstrated significantly improved survival compared with those with <12 nodes retrieved (log-rank $p<0.001$). Tumour stage was also significantly associated with survival, with T4 disease demonstrating poorer outcomes ($p<0.001$). In multivariable Cox regression analysis, lymph node yield ≥12 (HR 0.22, 95% CI 0.10-0.46) and T4 disease (HR 3.42, 95% CI 1.74-6.71) remained independent predictors of survival.

Conclusion

Adequate lymph node harvest and tumour stage are key determinants of survival following colorectal cancer surgery. However, substantial loss to follow-up limited survival analysis to a subset of patients, highlighting the need for strengthened cancer registries and structured follow-up systems to improve long-term outcome surveillance in Sri Lanka.

Introduction

Colorectal cancer (CRC) is among the most common malignancies worldwide and represents a major contributor to cancer-related mortality [1,2]. The burden of CRC has increased significantly in many Asian populations, reflecting demographic transitions, changing dietary patterns, and urbanization [3]. Several studies have demonstrated rising CRC incidence across South Asian populations, including Sri Lanka [4,5].

Early detection and effective surgical management remain the cornerstone of curative treatment for colorectal cancer. Surgical quality plays a critical role in determining long-term oncological outcomes. Adequate lymph node retrieval is particularly important because it ensures accurate staging and guides adjuvant therapy decisions [6,7]. International guidelines recommend retrieval of at least twelve lymph nodes during colorectal cancer surgery for appropriate pathological staging [6,7].

Advanced surgical techniques such as complete mesocolic excision with central vascular ligation have been proposed to

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improve oncological clearance and lymph node harvest [8,9]. Studies have shown that extended lymphadenectomy and improved surgical standardization may contribute to improved survival outcomes in colorectal cancer patients [10].

Despite increasing attention to colorectal cancer outcomes globally, limited data are available regarding surgical quality and long-term survival in South Asian populations. Understanding these factors is particularly important in healthcare systems where cancer surveillance and follow-up infrastructure remain underdeveloped.

This study aimed to evaluate clinicopathological characteristics, surgical quality indicators, and survival outcomes among patients undergoing colorectal cancer surgery in a tertiary referral centre in Sri Lanka.

Methodology

Study design and cohort

This retrospective cohort study included all patients undergoing colorectal cancer resection between 2019 and 2023 at a tertiary referral centre in Sri Lanka.

Clinicopathological data were extracted from histopathology reports and hospital records. Variables included age, sex, tumour location, tumour stage, lymph node yield, and histological features including lymphatic invasion, venous invasion, perineural invasion, tumour budding, and host lymphocytic response.

Survival data collection

Survival outcomes were determined through hospital records and telephone tracing where possible. Patients were classified as: (1) Traced - outcome status confirmed; or (2) Untraced - outcome status not verifiable. Baseline comparisons between traced and untraced patients were performed to evaluate potential selection bias.

Survival analysis

Overall survival was defined as the time from surgical resection to death from any cause. Survival time was calculated in months. Patients confirmed to be alive at the time of last follow-up were censored at the last known contact date.

Because complete survival data were not available for all patients, survival analysis was restricted to the subgroup of patients whose outcomes could be verified through hospital records, clinic follow-up documentation, or telephone tracing.

Kaplan-Meier methods were used to estimate survival probabilities with 95% confidence intervals, and comparisons between groups were performed using the log-rank test. Survival curves were generated for the following variables: lymph node yield, tumour T stage, lymphatic invasion, and tumour sidedness. Numbers at risk were displayed below each Kaplan-Meier curve.

A multivariable Cox proportional hazards regression model was constructed to identify independent predictors of survival. Variables entered into the model were selected based on clinical relevance and univariable analysis results, while limiting the number of predictors to maintain model stability given the number of observed deaths. Hazard ratios (HRs) with 95% confidence intervals (CI) were reported.

All statistical analyses were performed using SPSS version 28 (IBM Corp., Armonk, NY, USA).

Results

Study cohort

During the study period, 570 patients underwent colorectal cancer resection at the study centre. Survival status could be verified in 135 patients (23.7%), while 435 patients (76.3%) were untraceable at the time of outcome assessment.

Among the traced patients included in survival analysis, 47 deaths were recorded during the follow-up period and 88 patients were alive at the last confirmed contact. Kaplan-Meier survival analysis was therefore performed using the traced patient cohort.

Baseline comparison of traced and untraced patients

Baseline clinicopathological characteristics of traced and untraced patients are presented in Table 1. There were no statistically significant differences between the two groups with respect to age, sex distribution, tumour location, pathological T stage, or nodal stage. However, statistically significant differences were observed in lymph node yield distribution ($p<0.001$) and lymphatic invasion ($p=0.039$) between traced and untraced patients.

Overall survival

Kaplan-Meier survival analysis was performed among the 135 patients with confirmed follow-up. Median overall survival was not reached during the follow-up period.

Estimated overall survival probabilities were: 77.8% (95% CI

70.5-85.1%) at 12 months, 71.1% (95% CI 62.9-79.3%) at 24 months, 65.5% (95% CI 56.4-74.6%) at 36 months, and 59.9% (95% CI 49.8-70.0%) at 60 months. Kaplan-Meier survival curves for subgroup analyses are presented in Figures 1-4.

Table 1: Baseline characteristics of traced and untraced patients

Variable	Traced (n=135)	Untraced (n=435)	p value
Age (mean ± SD)	65.1 ± 13.4	62.8 ± 12.8	0.054
Male sex	62 (45.9%)	241 (55.4%)	0.067
Right-sided tumour	36 (26.7%)	118 (27.2%)	0.706
Left-sided tumour	65 (48.1%)	195 (44.9%)	
Rectal tumour	33 (24.4%)	120 (27.6%)	
T stage			0.409
T0-T1	7 (5.2%)	18 (4.2%)	
T2	27 (20.0%)	61 (14.4%)	
T3	76 (56.3%)	264 (62.1%)	
T4	25 (18.5%)	82 (19.3%)	
N stage			0.134
N0	75 (55.6%)	199 (45.7%)	
N1	35 (25.9%)	134 (30.8%)	
N2	25 (18.5%)	102 (23.4%)	
Lymph node yield group			<0.001
<12 nodes	74 (54.8%)	301 (69.2%)	
≥12 nodes	61 (45.2%)	134 (30.8%)	
Lymphatic invasion	83 (63.4%)	201 (47.4%)	0.039

Survival according to lymph node yield

Among the 135 patients included in survival analysis, Kaplan-Meier curves demonstrated a significant difference in survival according to lymph node yield (Figure 1). Patients with lymph node harvest ≥12 nodes demonstrated higher survival probabilities compared with those with <12 nodes retrieved (log-rank χ^2=19.52, df=1, p<0.001).

Median survival for patients with lymph node yield <12 nodes was 36 months, whereas median survival was not reached among patients with ≥12 nodes retrieved. Numbers at risk for the two groups are presented below the Kaplan-Meier curve.

Survival according to tumour T stage

Kaplan-Meier survival curves demonstrated a significant overall difference in survival according to tumour T stage among the traced cohort (log-rank χ^2=18.78, df=3, p<0.001) (Figure 2). Pairwise comparisons showed that patients with T4 tumours had significantly poorer survival compared with T1-T2 tumours (p<0.001) and T3 tumours (p<0.001). No significant difference was observed between T1-T2 and T3 tumours (p=0.182).

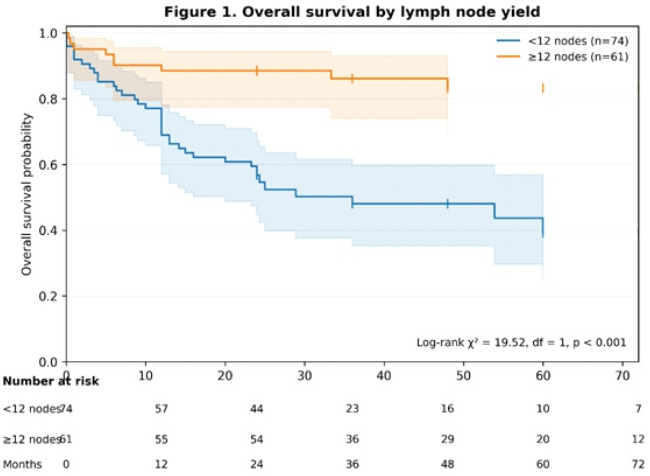

Figure 1: Kaplan-Meier survival curve according to lymph node yield.

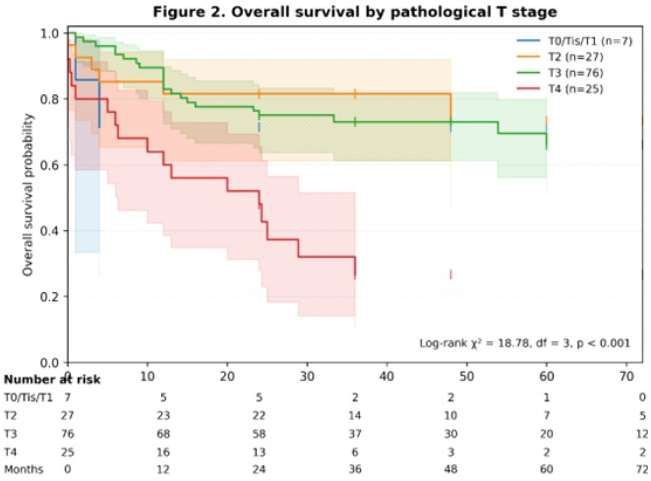

Figure 2: Kaplan-Meier survival curve according to tumour T stage.

Survival according to lymphatic invasion

Kaplan-Meier survival analysis demonstrated a significant difference in survival according to lymphatic invasion (log-rank χ^2=6.19, df=1, p=0.013) (Figure 3). Patients with lymphatic invasion present demonstrated lower survival probabilities compared with patients without lymphatic invasion.

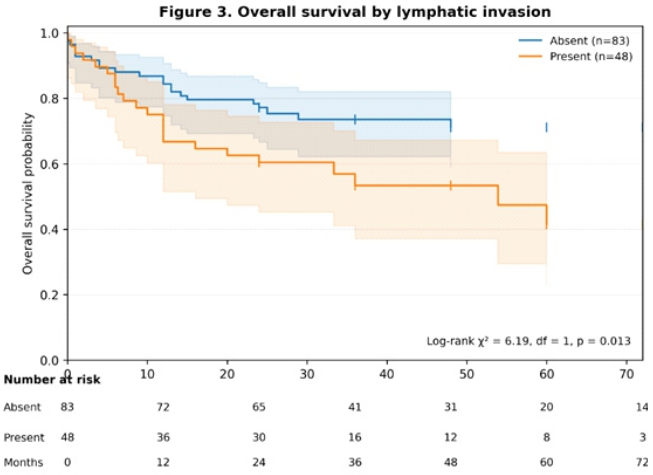

Figure 3: Kaplan-Meier survival curve according to lymphatic invasion

Survival according to tumour location

Kaplan-Meier survival curves comparing tumour sidedness demonstrated no statistically significant difference in survival between right-sided, left-sided, and rectal tumours (log-rank χ^2=0.92, df=3, p=0.820) (Figure 4).

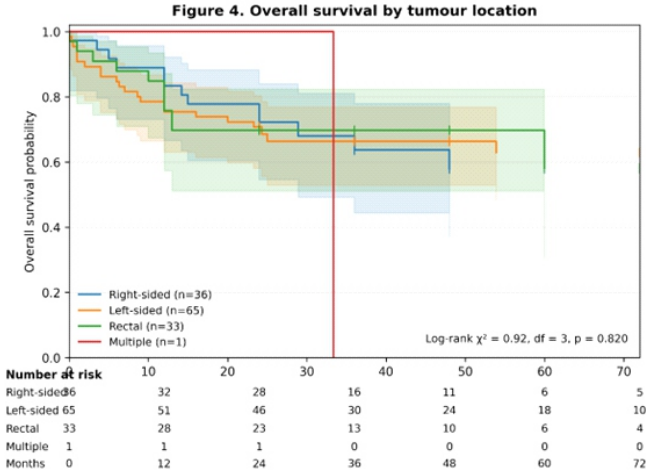

Figure 4: Kaplan-Meier survival curve according to tumour location.

Multivariable Cox Regression analysis

Multivariable Cox proportional hazards regression analysis was performed to identify independent predictors of survival. The results of the model are presented in Table 2.

Table 2: Multivariable Cox proportional hazards model

Variable	Hazard ratio	95% CI	p value
Lymph node yield ≥12	0.22	0.10-0.46	<0.001
T4 disease	3.42	1.74-6.71	<0.001

Two variables remained significantly associated with survival in the adjusted model: (1) Lymph node yield ≥12 nodes (HR 0.22, 95% CI 0.10-0.46, p<0.001); and (2) T4 disease (HR 3.42, 95% CI 1.74-6.71, p<0.001). Node-positive disease, lymphatic invasion, and host lymphocytic response were not independently associated with survival after adjustment.

Discussion

Colorectal cancer (CRC) remains one of the most significant causes of cancer morbidity and mortality worldwide. Global estimates indicate that CRC is among the leading malignancies affecting both men and women, with a steadily increasing burden particularly in low- and middle-income countries (LMICs) and Asian populations [1,2]. In South Asia, changing dietary patterns, urbanization, and increased life expectancy have contributed to rising incidence rates [3]. Sri Lanka is not exempt from this trend. Previous studies have shown that CRC incidence in Sri Lanka has been increasing over recent decades, with patients frequently presenting at more advanced stages of disease [4,5]. Against this background, evaluation of surgical quality and long-term outcomes is critical for understanding the effectiveness of current management strategies.

The present study provides a comprehensive evaluation of colorectal cancer surgery at a national referral center, integrating clinicopathological characteristics, surgical quality indicators, and survival outcomes. Our findings demonstrate that adequate lymph node harvest and tumour stage are the strongest determinants of survival within the traced patient cohort. At the same time, the study highlights systemic challenges in follow-up and outcome tracking, which are common limitations in many LMIC healthcare systems.

A key finding of this study is the association between lymph node yield and survival outcomes. Patients with a lymph node harvest of ≥12 nodes demonstrated significantly better survival compared with those with lower yields. This relationship remained independently significant in multivariable Cox regression analysis. Lymph node harvest has long been recognized as both a staging parameter and a surrogate marker of surgical quality in colorectal cancer. International guidelines recommend retrieval of at least 12 lymph nodes to ensure accurate pathological staging and optimal oncological outcomes [6,7]. Adequate lymph node retrieval reduces the risk of understaging and allows appropriate identification of node-positive disease, which is essential for guiding adjuvant therapy decisions.

The importance of lymph node yield has been demonstrated in numerous surgical series. Studies evaluating extended lymphadenectomy and central vascular ligation have reported improved oncological outcomes associated with more comprehensive lymph node dissection [8,9,10]. Techniques such as complete mesocolic excision with central vascular ligation aim to remove the entire mesocolic envelope containing regional lymphatics, thereby maximizing nodal clearance and improving staging accuracy [8]. Systematic reviews have also shown that extended lymphadenectomy is associated with increased lymph node harvest and improved disease-specific outcomes in selected patients [9]. Our findings are consistent with these observations and reinforce the importance of meticulous surgical technique and pathological assessment.

Tumour stage also emerged as a major determinant of survival. Patients with T4 tumours demonstrated significantly worse survival compared with earlier stages, reflecting the aggressive biological behaviour and increased likelihood of micrometastatic spread associated with advanced local invasion. The TNM staging system remains the cornerstone of colorectal cancer prognostication and guides treatment decisions across all stages of disease [11]. Advanced tumour penetration, particularly T4 disease, is associated with higher recurrence rates and poorer overall survival, highlighting the importance of early detection and timely intervention.

Interestingly, nodal stage did not remain independently associated with survival in the multivariable model. Although nodal involvement is traditionally considered one of the most powerful prognostic factors in colorectal cancer, the lack of independent significance in this study may be related to the relatively small size of the traced survival cohort. It is also possible that the strong association between lymph node yield and survival reflects the influence of surgical quality and staging accuracy rather than purely biological nodal disease burden. Several studies have suggested that higher lymph node counts may reflect more thorough surgical and pathological examination rather than increased metastatic burden alone [12,13].

The relationship between tumour location and survival has been widely debated in the colorectal cancer literature. Right-sided and left-sided colon cancers have distinct molecular and biological characteristics, and several studies have reported survival disparities between these tumour locations [14,15,16]. Right-sided tumours have been associated with poorer outcomes in some series, possibly due to differences in tumour biology, microsatellite instability patterns, and delayed presentation [14,16]. However, in the present study no statistically significant survival difference was observed between right-sided, left-sided, and rectal tumours. This finding may reflect the limited sample size of the traced cohort or differences in patient selection and treatment patterns. Larger population-based studies would be required to clarify whether tumour sidedness significantly influences outcomes in the Sri Lankan context.

Lymphatic invasion was associated with reduced survival in univariable analysis but did not remain independently significant in multivariable modelling. Lymphovascular invasion is widely recognized as an adverse prognostic factor in colorectal cancer and is associated with increased risk of nodal metastasis and distant recurrence [12]. The lack of independent significance in our study likely reflects the limited number of events available for multivariable analysis rather than absence of biological relevance. Similar findings have been reported in studies where lymphovascular invasion demonstrates prognostic value primarily in combination with other pathological factors.

An important aspect of the present study is the evaluation of follow-up completeness and its impact on survival analysis. Only a subset of patients had traceable follow-up data, which represents a major limitation in the interpretation of survival outcomes. Although baseline comparison demonstrated broad similarity between traced and untraced patients across major demographic and stage variables, significant differences in lymph node yield distribution and lymphatic invasion were observed. This indicates that the traced subgroup may not fully represent the entire surgical cohort and introduces potential selection bias in survival estimates.

Incomplete follow-up is a recognized challenge in many developing healthcare systems. Lack of centralized cancer registries, patient migration, and fragmented healthcare documentation contribute to difficulties in long-term outcome tracking. Previous regional studies have highlighted similar challenges in maintaining reliable cancer surveillance systems in South Asia [4]. Strengthening national cancer registries and establishing structured follow-up programs would greatly enhance the quality of outcome data and enable more robust evaluation of oncological care.

Despite these limitations, this study provides valuable insights into colorectal cancer surgery in a national referral center. The findings emphasize the critical importance of surgical quality, particularly adequate lymph node harvest, in determining patient outcomes. They also highlight systemic

gaps in follow-up infrastructure that may limit accurate assessment of long-term survival.

Future research should focus on developing prospective colorectal cancer registries and standardized follow-up protocols. Integration of surgical, pathological, and oncological data within a centralized registry would allow more comprehensive evaluation of treatment outcomes and facilitate continuous quality improvement in cancer care delivery.

Conclusion

This study provides a comprehensive evaluation of colorectal cancer surgery at a national referral center in Sri Lanka, highlighting key determinants of oncological outcomes and systemic challenges in follow-up. Adequate lymph node harvest and tumour stage emerged as the most important factors associated with survival in the traced patient cohort. Patients with lymph node yield ≥12 demonstrated significantly improved survival, reinforcing the importance of adequate nodal retrieval as both a staging requirement and a marker of surgical quality in colorectal cancer management [6,7]. These findings are consistent with international evidence demonstrating that meticulous surgical technique and appropriate lymphadenectomy are critical for accurate staging and optimal oncological outcomes [8,9,10].

However, the study also underscores important limitations in outcome surveillance, as survival analysis was restricted to a subset of patients with traceable follow-up. Differences observed between traced and untraced patients indicate that survival estimates must be interpreted cautiously and may not fully represent the entire surgical cohort. Strengthening national cancer registries and establishing structured follow-up systems will be essential for improving outcome monitoring and guiding future colorectal cancer management in Sri Lanka [4].

Limitations

Several limitations of this study should be acknowledged. First, survival analysis was restricted to the subset of patients whose outcome status could be verified. Only 135 of the 570 patients in the surgical cohort had traceable follow-up data. Although baseline comparison showed broad similarity between traced and untraced patients across most demographic and stage variables, significant differences were observed in lymph node yield distribution and lymphatic invasion. This introduces the possibility of selection bias and limits the generalizability of survival estimates derived from the traced subgroup.

Second, the retrospective nature of the study inherently introduces limitations related to data completeness and documentation accuracy. Clinicopathological information was extracted from existing hospital records and histopathology reports, and certain potentially relevant variables-such as adjuvant therapy details, recurrence patterns, comorbidity indices, performance status, and surgical margin status-were not consistently available for analysis. These factors may influence survival outcomes and their absence limits the ability to fully adjust for potential confounding.

Third, follow-up data were obtained through hospital documentation and telephone tracing, which may introduce recall bias and inconsistencies in outcome reporting. Additionally, missing data were handled using complete-case analysis without imputation. Histopathological reporting was based on routine institutional pathology reports, and central pathology review was not performed.

Fourth, the survival cohort size was relatively small compared with the overall surgical population, limiting the statistical power of multivariable modelling. Although Cox proportional hazards analysis was performed using clinically relevant variables, the number of covariates that could be included in the model had to be restricted to avoid model instability. Consequently, some potentially important prognostic factors described in previous studies may not have been fully captured in the present analysis [12].

Fifth, multiple subgroup survival comparisons were performed, which may increase the risk of Type I error.

Finally, the study represents the experience of a single tertiary referral centre. While this provides valuable insight into surgical outcomes within a specialized institutional setting, the findings may not fully reflect patterns of colorectal cancer management across other healthcare institutions in the country.

Future directions

Despite these limitations, the present study highlights several important opportunities for improving colorectal cancer care and outcome monitoring in Sri Lanka. One of the most critical priorities is the development of structured follow-up systems and national cancer registries capable of capturing long-term patient outcomes. Reliable registry infrastructure would allow more accurate survival estimation, facilitate population-based research, and support continuous quality improvement in cancer care delivery [4].

Future research should also focus on prospective multicentre studies that integrate surgical, pathological, and oncological data across multiple institutions. Such collaborative approaches would provide a more representative assessment of colorectal cancer management and help identify regional variations in surgical quality and treatment outcomes.

In addition, further investigation into surgical techniques that optimize oncological clearance may help improve patient outcomes. Standardized approaches such as complete mesocolic excision with central vascular ligation have been associated with improved lymph node harvest and potentially better oncological results in colon cancer surgery [8,9]. Evaluating the implementation of these techniques within local surgical practice may provide valuable insights into quality improvement strategies.

Finally, greater emphasis on early detection and screening programs may help reduce the burden of advanced colorectal cancer in the region. Increasing awareness, improving access to diagnostic services, and strengthening national screening initiatives could contribute to earlier diagnosis and improved survival outcomes in the future [1,2].

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Clinical trial registration

Not applicable.

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