Abstract

Background

The impact of obesity on survival is known to vary in different cancers. Advanced biliary tract cancer was rarely analyzed about the relationship between obesity and prognosis. We performed this study to evaluate the BMI and body weight change as prognostic factors for advanced biliary tract cancer patients with palliative chemotherapy.

Methods

Between January 2005 and December 2016, two hundred and seventy-six patients who underwent chemotherapy for biliary tract cancer were retrospectively analyzed. The relationship between BMI (kg/m²) and clinical outcomes including overall and progression-free survival was assessed. Additionally the relationship between change in body composition and overall survival was evaluated.

Results

Median overall survival was 9.7 months for underweight patients, 10.1 months for normal patients, 15.8 months for overweight group, 13.1 months for obese patients, respectively. (p = 0.047) Univariate analysis showed that BMI, stage III, age less than 64 year-old, gall-bladder cancer, operation, radiotherapy and ECOG performance were significantly associated with better survival. Compared with normal patients, overweight patients (BMI 23–24.9kg/m²) had a reduced risk of mortality in multivariate analysis (HR 0.632; 95% CI 0.436–0.918, p = 0.016). In the additional analysis for the effect of changes in body weight and BMI to the overall survival, decrease in body weight and BMI (HR 1.410, 95% CI 1.168–1.986, p = 0.046) was associated with a shorter in overall survival.
Conclusion

Overweight status and the maintenance of body weight during the initial period of chemotherapy are important and independent predictors of better overall survival in advanced biliary tract cancer patients.

Introduction

Biliary tract cancer (BTC) is a rare but fatal neoplasm that arises from biliary epithelium. Biliary tract cancer consists of gallbladder cancer and cholangiocarcinoma categorized as an intrahepatic duct, hilar, and distal bile duct tumor. Prognoses of both gallbladder cancer and cholangiocarcinoma are known to be very poor. The median survival of patients with unresectable biliary tract cancer is reportedly 3 to 6 months with or without biliary drainage [1].

The prevalence of obesity has increased markedly over the past few decades, and obesity has become a major burden on global public health, especially in developed countries. Obesity is considered a major risk factor for the progression of many chronic diseases. However, many studies have demonstrated that obesity is subject to the so called 'Obesity Paradox,' in which it acts a protective factor in patients with chronic diseases such as cardiovascular, chronic kidney disease, chronic obstructive pulmonary disease, and rheumatoid arthritis [2].

Numerous researches have investigated the factors affecting clinical outcomes of the patients with cancer. In studies investigating the association of body mass index (BMI) with clinical outcomes in many kinds of cancer patients, an increased BMI has been associated with mixed outcomes [3, 4].

Few studies have investigated the BMI in patients with biliary tract cancer, and most of these evaluated the association of BMI and the risk of developing cancer. Many studies have reported that obesity increased the risk of developing biliary tract cancer [5–7]. In a study published in 2003, mortality increased with increasing BMI among patients with gallbladder cancer [8]. Conversely, in a study with 55 cholangiocarcinoma patients, there were no significant differences between BMI and survival outcome [9]. However, this was a small-scale study of patients undergoing surgery. Therefore, the results of these studies cannot be applied directly to unresectable BTC, which accounts for most BTCs. In addition, no studies have evaluated BMI and body weight changes as prognostic factors in patients who underwent chemotherapy, which is the mainstay of treatment for unresectable BTCs.

Taking these points into consideration, we evaluated the association between BMI and clinical outcomes including overall and progression-free survival and whether body weight changes can be a prognostic factor for advanced BTC patients receiving palliative chemotherapy.

Methods

Study subjects and data collection

We retrospectively reviewed the medical records of 425 patients who had been diagnosed with advanced biliary tract cancer and underwent palliative chemotherapy between January 2005 and December 2016. All subjects were diagnosed with CCA on the basis of histological or cytological confirmation.
The following data were obtained for each patient: age, sex, BMI, comorbidities, Eastern Cooperative Oncology Group Performance Status (ECOG-PS), tumor location, tumor stage, existence of distant metastases, regimen of chemotherapy. Patients were only included if they were at least AJCC tumor stage III, ECOG-PS ≤ 2, Charlson comorbidity index ≤ 5, had no history of other types of cancer, were previously untreated with palliative chemotherapy, had undergone at least three cycles of chemotherapy, and did not have active biliary infection at the time of chemotherapy.

CT scans performed at the time of initial chemotherapy and 2-month follow-up were used to quantify skeletal muscle mass. Two adjacent axial images within the same series were selected for the analysis of the third lumbar vertebra (L3) skeletal muscle and the mean of the 2 measurements was calculated. Muscles were quantified within a Hounsfield unit (HU) range of -29 to 150 HU [10]. Muscle mass was normalized for height in meters squared (m²) and reported as the lumbar skeletal muscle index (SMI; cm²/m²) [11].

Overall, 276 patients were analyzed in this study. All patients were followed until December 2016, and observations were censored at the time of death or loss to follow-up. The study protocol was approved by the institutional review board of Seoul National University Hospital. All studies were conducted according to Declaration of Helsinki. Requirement for informed consent was waived for this retrospective study and all patients’ medical records were fully anonymized before analysis.

**Definition of the variables**

In our hospital, we conducted laboratory tests and measured patients’ height and weight for dose adjustment on the first day of each chemotherapy cycle. These data were also used to determine the BMI. In this study, BMI measured at the start of chemotherapy was used for classification based on the WHO classification, Asia-Pacific guidelines of obesity classification and referring to the clinical practice guidelines for overweight and obesity in Korea: underweight (BMI < 18.5 kg/m²), normal weight (BMI: 18.5–22.9 kg/m²), overweight (23–24.9 kg/m²), and obese (≥ 25 kg/m²). [12] Changes in body weight were categorized as follows: -5% to 5% (no change), -10% to -5%, more than -10%, 5% to 10%, and more than 10%. Sarcopenia was defined as SMI ≤ 41 cm²/m² based on previous studies [11, 13].

Tumor location was classified as gallbladder cancer or bile duct cancer, and the latter was categorized into intrahepatic, proximal bile duct (including Klatskin tumor), and distal bile duct. The stage of the tumor was recorded according to the AJCC TNM staging classification (7th ed.). Progression-free survival (PFS) was defined as the time interval from the start of the palliative chemotherapy to disease progression, and overall survival (OS) was defined as the time from start of palliative chemotherapy to death from any cause or last day of follow-up.

**Statistical analysis**

Data are shown as the number (%) for categorical variables, the mean ± standard deviation (SD) for continuous variables and the median for survival. The significance of differences in clinical parameters among BMI groups was assessed by the Chi-squared test, one-way analysis of variance (ANOVA), and Fisher’s extract test as appropriate. Overall, survival and progression-free survival curves were constructed by the Kaplan–Meier method and compared using the log rank test. A multivariable Cox proportional hazards model was used to identify the independent predictors of PFS and OS. Results were expressed as hazard ratios (HRs) and 95% confidence intervals (CIs). Statistical significance was assumed at a confidence level of 0.05. Statistical analyses were performed using SPSS 23 (SPSS, Chicago, IL, USA).
Results

Baseline characteristics of patients

Baseline characteristics of the 276 patients are summarized in Table 1. There were 177 male and 99 female patients aged 26 to 94 years (63.7 ± 9.9). Median survival of the patients was 11.1 months (range: 1.5–71.6, 11.1 ± 10.3). Of the 276 patients included in this study, 30 (10.9%) were underweight, while 113 (40.9%), 64 (23.2%), and 69 (25.0%) patients were classified as normal, overweight, and obese, respectively. The mean SMI value was 43.3 ± 15.5 cm²/m² and showed no statistical differences among BMI class. 94 (33.8%) patients were sarcopenic at the time of initial chemotherapy and the proportion of patients with sarcopenia among BMI class had no significant differences. Cancers were located as follows: 107 (38.8%) intrahepatic

Table 1. Baseline characteristics of patients.

|                      | All          | BMI (kg/m²) | p-value |
|----------------------|--------------|-------------|---------|
|                      |              | Underweight | Normal  | Overweight | Obese  |
|                      |              | (< 18.5)    | (18.5–22.9) | (23–24.9) | (≥25)  |
|                      |              | N = 30      | N = 113 | N = 64     | N = 69  |
| Age (mean, y)        | 63.7 (26–94) | 61.3        | 64.4    | 64.0       | 63.5    | 0.440   |
| Sex (%)              |              |             |         |            |         |         | <0.001  |
| Male                 | 177 (64.1%)  | 25 (83.3%)  | 83 (73.5%) | 34 (53.1%) | 35 (50.7%) |
| Female               | 99 (35.9%)   | 5 (16.7%)   | 30 (26.5%) | 30 (46.9%) | 34 (49.3%) |
| Location             |              |             |         |            |         | 0.138   |
| Proximal bile duct (including hilar area) | 67 (24.3%)    | 3 (10.0%)  | 32 (28.3%) | 10 (15.6%) | 22 (31.9%) |
| Distal bile duct     | 28 (10.1%)   | 4 (13.3%)   | 10 (8.8%)  | 5 (7.8%)   | 9 (13.0%)  |
| Gallbladder          | 74 (26.8%)   | 5 (16.7%)   | 33 (29.2%) | 23 (35.9%) | 13 (18.8%) |
| Intrahepatic bile duct | 107 (38.8%) | 18 (60.0%)  | 38 (33.6%) | 26 (40.6%) | 25 (36.2%) |
| Stage                |              |             |         |            |         | 0.356   |
| III                  | 43 (15.5%)   | 3 (10.0%)   | 11 (9.7%)  | 11 (17.2%) | 17 (25.0%) |
| IV                   | 233 (84.5%)  | 27 (90.0%)  | 102 (90.3%) | 53 (82.8%) | 52 (75.0%) |
| OP status            |              |             |         |            |         | 0.490   |
| No                   | 234 (81.0%)  | 25 (83.9%)  | 91 (80.7%) | 54 (83.3%) | 54 (77.9%) |
| Yes                  | 52 (19.0%)   | 5 (16.1%)   | 22 (19.3%) | 10 (16.7%) | 15 (22.1%) |
| Gemcitabine-based chemotherapy |          |             |         |            |         | 0.297   |
| No                   | 64 (23.2%)   | 4 (13.3%)   | 27 (23.9%) | 22 (34.4%) | 11 (15.9%) |
| Yes                  | 212 (76.8%)  | 26 (86.7%)  | 86 (76.1%) | 42 (65.6%) | 58 (85.1%) |
| ECOG-PS              |              |             |         |            |         | 0.056   |
| 0                    | 44 (15.9%)   | 6 (20.0%)   | 12 (10.6%) | 14 (21.9%) | 12 (17.4%) |
| 1                    | 211 (76.4%)  | 20 (66.7%)  | 88 (77.9%) | 48 (75.0%) | 55 (79.7%) |
| 2                    | 22 (7.7%)    | 4 (13.3%)   | 13 (11.5%) | 2 (3.1%)   | 2 (2.9%)  |
| RT status            |              |             |         |            |         | 0.123   |
| No                   | 240 (87.0%)  | 25 (80.6%)  | 96 (85.0%) | 55 (85.9%) | 64 (92.8%) |
| Yes                  | 36 (13.0%)   | 5 (19.4%)   | 17 (15.0%) | 9 (14.1%)  | 5 (7.2%)  |
| SMI (cm²/m²)         | 43.3±15.5    | 45.8±14.5   | 40.5±14.4 | 45.2±13.1 | 43.9±19.9 | 0.294   |
| Sarcopenia (SMI ≤41 cm²/m²) |       |             |         |            |         |         |
| No                   | 182 (66.2%)  | 19 (64.5%)  | 71 (63.0%) | 45 (71.2%) | 47 (67.6%) | 0.594   |
| Yes                  | 94 (33.8%)   | 11 (35.5%)  | 42 (37.0%) | 19 (28.8%) | 22 (32.4%) |

Abbreviations: BMI, body mass index; OP, operation; ECOG-PS, Eastern Cooperative Oncology Group Performance Status; RT, Radiation therapy; SMI, Skeletal muscle index.

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bile duct, 67 (24.3%) proximal bile duct (including hilar area), 28 (10.1%) distal bile duct, and 74 (26.8%) gallbladder. Overall, 233 (84.5%) patients were AJCC stage IV at the time of palliative chemotherapy. 44 (15.9%) had an ECOG-PS of 0, 211 (76.4%) had an ECOG-PS of 1, and 22 (7.7%) had an ECOG-PS of 2. Most of the patients (212, 76.8%) received gemcitabine-based palliative chemotherapy. 52 (19.0%) patients received operation before chemotherapy for curative resection or palliative intent and 43 (15.5%) patients received radiotherapy.

Study population was stratified by 2 groups, with age of 64 years and sex then the body weight and composition were analyzed. When divided by the age of 64 years, there was no difference between the two groups in initial value and 2-month value of BMI, and the percentage of body weight change did not differ either. In terms of body composition, the initial value of muscle mass was significantly higher in patients younger than 64 years of age, but there was no statistical significance in 2-month value and rate of change. When analyzed by gender, women had a significantly higher initial BMI than men, but the other indicators did not show any gender differences. (Table 2). And there was no significant differences in the initial SMI, rate of the change and 2-month SMI according to the initial BMI class. (Table 3).

**Progression-free survival according to BMI class**

Overall, 266 patients showed progression of disease during follow-up, and the median PFS was 6.8 months (range: 0.6–33.3, 6.8±6.0). No statistically significant difference in PFS was observed according to BMI. Median PFS was 6.6 months, 6.3 months, 8.1 months and 6.5 months in the normal weight, underweight, overweight, and obese group, respectively (Fig 1). Univariate analysis revealed that non-sarcopenia, gemcitabine-based chemotherapy, stage III,
younger age group, and radiotherapy were associated with longer PFS. Upon multivariate analysis, only stage III was independent factor for longer PFS (Table 4).

**Overall survival according to BMI class**

A total of 236 deaths or cases of loss of follow-up were recorded in 276 patients. Of the 276 patients, 182 were confirmed to have died and 54 patients had follow-up loss. The mean follow-up period was 11.9 months (1.6–71.6). The median OS was 9.7 months for underweight patients, 10.1 months for normal patients, 15.8 months for the overweight group and 13.1 months for obese patients. Univariate analysis showed that BMI, stage III, age less than 64 years old, gallbladder cancer, operation, radiotherapy and ECOG performance were significantly associated with better survival. Multivariate analysis was performed and adjusted for age, sex, location, stage, disease status, operation, radiotherapy and ECOG performance. Compared

**Fig 1. Progression-free survival according to BMI status at baseline.**

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with normal weight patients, overweight patients (BMI 23–24.9 kg/m²) had a reduced risk of mortality on multivariate analysis (Fig 2, Table 5, HR 0.632; 95% CI 0.436–0.918, p = 0.016) In addition to BMI, tumor location was shown to be associated with overall survival.

**Overall survival according to change in body weight, composition and BMI**

We conducted additional analyses to determine if changes in body weight, BMI and body composition affected overall survival. The median overall survival was longest in the group of...
no change, while the group in which body weight decreased by more than 10% showed the worst prognosis (Table 6, Fig 3A). Survival analysis of the BMI class revealed a statistically significant decrease in groups in which BMI class had decreased. Overall survival was longest in the group without change of BMI class (Table 6, Fig 3B). Greater changes in body weight were associated with less overall survival.

During the initial 2 months, 119 (41.9%) patients suffered decreased SMI by more than 10%. The overall survival of maintained SMI group was 13.4 months and 9.4 months in the decreased SMI group, indicating statistically significant decrease in the survival time in the decreased SMI group. Decreased SMI was associated with poor overall survival. (Table 6, Fig 3C.)

We evaluated the overall survival according to initial muscle mass and change in muscle mass in each BMI group. Overall survival was not different significantly according to initial sarcopenia or decrease in muscle mass during 2 months among underweight, normal weight, and obese groups. In the overweight group, the overall survival of the initial sarcopenic patients was significantly lower than that of the non-sarcopenic group. The decrease in muscle mass did not significantly affect overall survival. (Table 7)
Discussion

Although the obesity paradox has been recognized in many kinds of cancer, the association between weight status and the prognosis of biliary tract cancer patients has seldom been reported. Several studies have demonstrated an association between obesity and risk of biliary tract cancer incidence, but none have investigated prognosis of biliary tract cancer according to weight status to the best of our knowledge. This is the first report that showed overweight
status can prognosticate better survival in patients with advanced biliary tract cancer who received palliative chemotherapy.

In this study, survival outcome was better in the overweight group than other groups. These findings are consistent with the results of other previous cancer studies that examined the relationship between obesity and survival outcome. In many studies, the pattern of survival outcome was similar to that of U shape [14], which is concordant with the results of the present study. It is worth of noting that BMI at the onset of chemotherapy is associated with overall survival, independent of skeletal muscle mass.

As clinical/biological markers that can reflect cachexia/proteolysis, change in skeletal muscle mass have been focused on. In previous studies, sarcopenia at diagnosis and decrease in muscle mass during clinical course were known to have association with poor overall survival in patients with advanced cancer [11, 15, 16]. In this study, there was a significant correlation between the maintenance of muscle mass and overall survival as previous studies. Significant decrease in muscle mass was associated with poor overall survival but initial muscle mass itself did not affect significant difference in overall survival. Preceding studies were mainly based on

| Table 6. Overall survival according to change in body weight, BMI class and SMI during the first two months of chemotherapy. |
|---------------------------------------------------------------|
| **N** | **OS (median, mo)** | **Univariate** | **Multivariate** |
| Body weight change | | | | |
| -5% to 5% | 173 | 13.7 | 1 | 1 |
| -10% to -5% | 38 | 9.1 | 1.428 (0.947–2.154) | 0.89 | 1.076 (0.651–1.778) | 0.776 |
| more than -10% | 14 | 5.8 | 2.686 (1.394–5.175) | 0.003 | 1.757 (0.670–4.610) | 0.252 |
| 5% to 10% | 43 | 11.9 | 1.000 (0.663–1.507) | 0.999 | 0.860 (0.491–1.504) | 0.860 |
| more than 10% | 8 | 9.9 | 1.283 (0.563–2.923) | 0.554 | 1.135 (0.407–3.164) | 0.809 |
| BMI class change | | | | |
| 0 | 214 | 12.6 | 1 | 1 |
| +1 | 26 | 13.8 | 0.870 (0.572–1.323) | 0.470 | 0.931 (0.730–1.780) | 0.436 |
| -1 | 33 | 11.7 | 1.062 (0.743–1.519) | 0.740 | 1.252 (0.680–2.306) | 0.471 |
| more than -2 | 3 | 8.4 | 1.406 (1.049–1.691) | 0.041 | 1.410 (1.168–1.986) | 0.046 |
| SMI change | | | | |
| Maintained | 157 | 13.4 | 1 | 1 |
| Decreased | 119 | 9.4 | 1.410 (1.029–1.932) | 0.033 | 1.391 (1.015–1.907) | 0.04 |

Abbreviations: N, number; OS, overall survival; BMI, body mass index; SMI, skeletal muscle index.

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![Fig 3. Overall survival according to change of body weight (A), BMI class (B) and SMI (C) during the first two months of chemotherapy.](https://doi.org/10.1371/journal.pone.0195118.g003)
the western population, which suggests that current threshold for sarcopenia may not fit well with the Asian population. There was a study that the cutoff value for sarcopenia were set arbitrarily by ROC analysis in Asian population [16], but more studies would be needed for validation. Skeletal muscle mass index has been known as a useful indicator for determining sarcopenia in several studies, but the most adequate method and its threshold for sarcopenia are still under debate [13, 17]. Although not statistically significant, this study showed that overall survival has tendency to decrease in sarcopenic patients and decrease in overall muscle mass, independent of initial muscle mass, was associated with decrease in overall survival and those results are in line with other studies.

There are several possible reasons for the relatively good prognosis of the overweight group. One potential explanation is that fat can act as the main energy reservoir of the body; therefore, an adequate amount of body fat confers a survival advantage in cancer patients [18]. Another possibility is that BMI is not an accurate measure of body adiposity and composition, and cannot distinguish lean body mass from fat mass. Indeed, muscular individuals could be included in the overweight group during classification through BMI [19]. Finally, the low-body weight group may have a higher mean age, more comorbidities, and a lower performance status than the other groups. Thus, older age and comorbidities may act as possible confounding factors when attempting to determine the association between BMI categories and survival outcome in cancer patients [20, 21].

The poor survival outcome of the underweight group may be related to the loss of muscle and fat mass because of sarcopenia and cachexia. Several studies also demonstrated that sarcopenia has been found to be associated with poor overall prognosis in patients with cancer [15, 22–25]. Cancer-induced cachexia is known to be not fully reversible by usual nutritional support, leading to progressive functional impairment, reduced tolerance to treatment, and finally decreased survival rates [19, 26, 27].

In contrast to overweight, obesity was not associated with longer survival in patients with cancer in advanced stages. There is also a high possibility that co-morbidities, especially those associated with metabolic diseases, could increase. The increase in excess visceral adipose tissue is associated with an increase in interleukin-6 (IL-6), free fatty acid, and tumor necrosis factor-alpha (TNF-a). This increase in cytokine causes increases in insulin resistance and pro-angiogenic factors, and promotes chronic inflammatory state leading to development of the tumor microenvironment [28]. This may be the cause of development of chemo-resistance and poor response to chemotherapy. In general, when chemotherapy is given, patients with a BSA greater than 2 are more likely to undergo dose-capping with BSA 2 for fear of toxicity. These unnecessary reductions in chemotherapy dosing may have resulted in poor treatment results among obese patients compared to overweight patients [29].

As the degree of weight change in the first 2 months of chemotherapy increased, the overall survival tended to decrease. Previous studies of other carcinomas have reported that patient

| BMI            | Sarcopenia | Non-sarcopenia | p-value | Maintained | Decreased | p-value |
|----------------|------------|----------------|---------|------------|-----------|---------|
| Underweight    | 7.58       | 10.7           | 0.226   | 12.2       | 7.8       | 0.105   |
| Normal         | 7.6        | 10.9           | 0.062   | 10.8       | 8.3       | 0.199   |
| Overweight     | 11.5       | 22.2           | 0.028   | 16.6       | 11.6      | 0.5     |
| Obese          | 8.4        | 17.1           | 0.101   | 15.2       | 10.5      | 0.594   |

Abbreviations: SMI, skeletal muscle index; BMI, body mass index.
weight loss has an adverse effect on clinical outcome [30], which is concordant with the results of the present study. Weight loss in the early period of chemotherapy is known to occur in about 85% of advanced cancer patients [31], and tumor-induced hyper-metabolism [32] may be the first cause of the weight loss. It is possible that increased tumor burden due to cancer progression resulted in loss of weight and decreased overall survival. In addition, as tumors with high malignant potential require more energy for growth, it is possible that aggressive biologic tumor behavior is expressed in the form of weight loss.

To evaluate whether tumor biology has significant effects in the initial nutritional status and the progression of cachexia, we compared the absolute value of SMI and the ratio of sarcopenia in each BMI class at the beginning of chemotherapy and 2 month later. No significant differences were found in the aspect of muscle mass. Therefore, we assumed that BMI can be one of the predictors of overall survival independent of change in muscle mass.

There was no significant association between BMI category and progression-free survival. Progression of the tumor may primarily be due to factors such as tumor burden which is represented by stage, biology and chemo-resistance rather than host factors, as reported for other types of malignancies. However, significant differences in the final outcome according to the BMI category indicate the importance of host factors such as infection control, adequate nutritional status and its maintenance, which can be achieved by adequate supportive care during treatment.

One major limitation of our study is that it was retrospective, as were previous studies that investigated the association between BMI and survival outcome in other cancers. Accordingly, it may be difficult to apply these results to the general population because they are based on a single tertiary center and the criteria for overweight and obese groups were applied slightly differently because of ethnicity. Furthermore, because we only evaluated the BMI at the time of initiation of chemotherapy, the results could not reflect the changes in BMI during the long-term follow-up period and its impact. Another limitation is that BMI is not an accurate measure of body adiposity and composition as described above. Combining tools such as waist circumference, waist-to-hip ratio, and skinfold with BMI may be better for evaluating body components. Such analyses can be accomplished by CT, MRI, and dual-energy X-ray absorptiometry. Overall, further efforts are needed to distinguish between adipose tissue (SAT) and visceral adipose tissue (VAT).

Nevertheless, to the best of our knowledge, this is the first study to demonstrate the association of BMI, body weight change and prognosis in patients with advanced BTC. The results presented herein indicate that evaluation of nutritional status in patients during chemotherapy is important. Therefore, clinicians should pay attention to the weight and nutritional status of patients at the time of chemotherapy and provide supportive care to maintain adequate nutritional status. Moreover, there is the possibility to improve clinical outcome by more aggressive chemotherapy in specific groups according to BMI.

Conclusion

Overweight status at the time of chemotherapy and maintenance of body weight during the initial period of chemotherapy are important prognostic factors of better overall survival for patients with advanced biliary tract cancers.

Supporting information

S1 File. Dataset for body mass index and skeletal muscle index.
(ZIP)
Author Contributions

Conceptualization: Jinwoo Kang, Sang Hyub Lee.

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