

EARLY LAPAROSCOPIC CHOLECYSTECTOMY IN GALLSTONE PANCREATITIS

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Abstract: Gallstones are one of the major causes of “acute pancreatitis” and thus “laparoscopic cholecystectomy” should be planned to remove these stones. However, timing of surgery has been a topic of debate and it is still unclear that which option provides better outcomes. **Objectives:** To compare the outcomes of early versus delayed laparoscopic cholecystectomy in gallstone pancreatitis. **Methods:** This two-phase quasi-experimental study was conducted at the Department of General Surgery, Nawaz Sharif Medical College / Aziz Bhatti Shaheed Teaching Hospital, Gujrat, Pakistan from May 2024 till August 2024. A total of 78 patients admitted with “acute gallstone pancreatitis” were included. Half of the patients in first phase of the study underwent “early laparoscopic cholecystectomy” while remaining half in second phase of the study underwent “delayed laparoscopic cholecystectomy”. Outcomes between both the groups were compared. Data was analyzed through SPSS version 20. **Results:** Mean age was 42.97 ± 5.68 years. There were 15 (19.23%) male and 63 (80.77%) female patients. Mean BMI was 32.95 ± 4.98 kg/m². Mean operative time in “early LC” group was 76.28 ± 9.71 minutes while in “delayed LC” group, it was 86.43 ± 9.80 minutes ($p < 0.001$). There was significantly less frequency of presence of adhesions in the operative field ($p = 0.01$) and intra-operative bleeding (0.05) in “early LC” group. Mean hospitalization length in “early LC” group was 6.71 ± 1.33 days while in “delayed LC” group, it was 12.33 ± 3.08 days ($p < 0.001$). Frequency of recurrent pancreatitis in “early LC” group was significantly less as compared to “delayed LC” group. ($p = 0.002$). **Conclusion:** “Early laparoscopic cholecystectomy” is a safer and better surgical option as compared to “delayed laparoscopic cholecystectomy” for management of “gallstone pancreatitis”.

Keywords: Cholelithiasis, Gallstones, Laparoscopic cholecystectomy, Outcome, Pancreatitis

Introduction

“Acute pancreatitis” is a common gastrointestinal disease that often leads to hospitalization. In extreme cases, it is linked to high rates of death from complications (1). The etiological causes of “acute pancreatitis” exhibit significant variation across different geographical regions and socioeconomic groups and the most prevalent factors contributing to this condition include gallstones, excessive alcohol use and hypertriglyceridemia (2). In Pakistan, prevalence of acute pancreatitis has been reported at 41.67% (3). The pathophysiology of “acute pancreatitis” is defined by the untimely activation of the enzyme “trypsinogen” to “trypsin” inside the acinar cell instead of the duct lumen. This results in premature activation of cell death due to elevated ductal pressures secondary to duct obstruction. Additionally, disruptions in calcium homeostasis and pH levels can also contribute to this disease (4). There are several clinical scores that are utilized to classify the severity of “acute pancreatitis” amongst which “Ranson score” and “BISAP score” are amongst the most common clinical scores used for this purpose (5). Obesity significantly increases the risk of developing asymptomatic gallstones and with the increasing prevalence of obesity across the globe, risk of gallstones and associated gallstone pancreatitis also has the potential to increase significantly (6). The gold-standard procedure for the treatment of symptomatic gallstones is “laparoscopic cholecystectomy (LC)” and it has almost completely replaced the conventional surgical option of open procedure (7). However, when it comes to the choice of ideal timing

of performing LC in patients suffering from “gallstone pancreatitis” that can provide best possible outcomes, it is still a topic of debate. At one end, there are studies that report significantly better outcomes with performing “early LC” as it not only reduces the operative time and hospitalization length but also help in reducing the complications associated with delayed surgery (8, 9). On the other hand, a large meta-analysis revealed no statistically significant difference between early and delayed LC for management of “acute gallstone pancreatitis” (10).

In order to address this discrepancy in previous literature regarding the choice of ideal timing of performing LC in patients suffering from “gallstone pancreatitis”, present study was conducted with the objective to compare the outcomes of early versus delayed LC in patients admitted with “acute gallstone pancreatitis” at a tertiary care hospital of Pakistan.

Methodology

This two-phase quasi-experimental study was conducted at the “Department of General Surgery, Nawaz Sharif Medical College / Aziz Bhatti Shaheed Teaching Hospital, Gujrat, Pakistan from May 2024 till August 2024” after obtaining approval from the ethical review board (ERB #:1684/24). Sample size was calculated using “WHO sample size calculator” by assuming following parameters:

- Level of significance = 5%
- Power = 80%

- Anticipated frequency of recurrent pancreatitis in early LC group = 0% (11)
- Anticipated frequency of recurrent pancreatitis in delayed LC group = 18% (11)

Calculated sample size was 78 (39 in each group).

Male and female adult patients, aged more than 18 years, who were admitted with “acute gallstone pancreatitis” were included in the study. Patients who had pancreatitis without presence of the gallstones, poorly controlled type 2 diabetes mellitus [defined as HbA1C% \geq 7.5% (12)], cardiopulmonary comorbidities, history of bleeding/coagulation disorder, history of smoking and alcohol consumption, patients who were mentally incapacitated, those lost to follow up and patients who were unfit to undergo general anesthesia were excluded from the study.

Study population was selected by using non-probability consecutive sampling technique. Prior to inclusion in the study, a written informed consent was signed by the patients. Diagnosis of acute pancreatitis was made as per standard protocol. In case serum amylase and lipase levels were raised by three times of more than the upper normal limit, patients were labelled to have “acute pancreatitis” (13). To identify presence of gallstones, ultrasound abdomen was used that was performed by an experienced radiologist with minimum of five years of experience. After this, baseline characteristics including age, gender, body mass index (BMI) and “Ranson score” were documented. All the patients underwent conservative management for pancreatitis.

During the first phase of study, patients were planned to undergo “early LC” (n = 39) which was defined as “LC performed within two weeks of acute gallstone pancreatitis” while in the second phase of the study, patients were planned to undergo “delayed LC” (n = 39) which was defined as “LC performed after two weeks of acute gallstone pancreatitis”. All the patients were comprehensively educated regarding the surgery. All the surgeries were performed by a team of senior surgeons constituted by one consultant, two senior registrars and three senior post-graduate trainees. All the surgeries were performed by “standard four port technique”. In all the patients, duration of surgery (in minutes) was documented. Any event of conversion of LC to “open cholecystectomy” was also documented. In addition, intra-operative complication was also documented. After the procedure, patients were kept admitted in the hospital ward and were given post-operative care as per institutional protocols. Hospitalization length was documented at the time of discharge from the hospital. Patients were followed up till ninety days after the surgery to assess for presence of any complications.

“Data was analyzed by using Statistical Package for Social Sciences (SPSS) 20. Quantitative data (age, BMI, Ranson score, operative time and hospitalization length) were represented using mean \pm standard deviation. Qualitative data (gender, conversion from LC to open cholecystectomy, intraoperative and post-operative complication) was represented by using percentage and frequency. Chi square test (for qualitative variables) and Student t-test (for quantitative variables) were used for comparison between groups. A p-value of \leq 0.05 was considered as statistically significant”.

Results

A total of 78 patients were included in this study. Mean age of the patients was 42.97 ± 5.68 years. There were 15 (19.23%) male and 63 (80.77%) female patients. Mean BMI of the patients was 32.95 ± 4.98 kg/m². Median Ranson score was 2 (0 – 5). Comparison of baseline characteristics between study groups is given below in table-I:

Mean operative time in “early LC” group was 76.28 ± 9.71 minutes while in “delayed LC” group, it was 86.43 ± 9.80 minutes (p < 0.001). None of the patients in both the groups registered an event of conversion of LC to an open procedure. Frequency of stone retention in “common bile duct (CBD)” in “early LC” (n = 39) group was 1 (2.56%) while none of the patients in “delayed LC” group (n = 39) had this complication (p = 0.31). Frequency of intra-operative bleeding in “early LC” (n = 39) group was 1 (2.56%) while in “delayed LC” group (n = 39) it was 6 (15.38%), (p = 0.05). Frequency of adhesion visualized in the operative field in “early LC” (n = 39) group was 2 (5.13%) while in “delayed LC” group (n = 39) it was 10 (25.64%), (p = 0.01). Comparison of intra-operative parameters and complications between study groups is given below in table-II:

Mean hospitalization length in “early LC” group was 6.71 ± 1.33 days while in “delayed LC” group, it was 12.33 ± 3.08 days (p < 0.001). In “early LC” group (n = 39), frequency of surgical site infection was 4 (10.26%) while in “delayed LC” group (n = 39), it was 1 (2.56%), (p = 0.17). During the ninety days follow up, no event of mortality was registered in any of the patients of present study. Pancreatic pseudocyst occurred in no patient in “early LC” group (n = 39) but in “delayed LC” group (n = 39) it occurred in 2 (5.13%) patients, (p = 0.15). In “early LC” group (n = 39), frequency of recurrent pancreatitis was 1 (2.56%) while in “delayed LC” group (n = 39), it was 11 (28.21%), (p = 0.002). Comparison of post-operative parameters and complications is given below in table-III.

Table 1: Comparison of baseline characteristics between study groups (n = 78)

Characteristic	“Early LC” (n = 39)	“Delayed LC” (n = 39)	p-value
Mean age	41.28 \pm 5.33 years	44.66 \pm 5.57 years	0.008
Gender			
Male	9 (23.07%)	6 (15.38%)	0.39
Female	30 (76.93%)	33 (84.62%)	
Mean BMI	32.83 \pm 5.60 kg/m ²	33.06 \pm 4.35 kg/m ²	0.84
Median Ranson score	2 (0 – 5)	2 (0 – 5)	0.62

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Table 2: Comparison of intra-operative parameters and complications between study groups (n = 78)

Intra-operative parameter / complication	“Early LC” (n = 39)	“Delayed LC” (n = 39)	p-value
Mean operative time	41.28 ± 5.33 years	44.66 ± 5.57 years	< 0.001
Conversion of LC to open procedure	0 (0%)	0 (0%)	--
Stone retention in common bile duct	1 (2.56%)	0 (0%)	0.31
Intra-operative bleeding	1 (2.56%)	6 (15.38%)	0.05
Adhesions in operative field	2 (5.13%)	10 (25.64%)	0.01

Table 3: Comparison of intra-operative parameters and complications between study groups (n = 78)

Post-operative parameter / complication	“Early LC” (n = 39)	“Delayed LC” (n = 39)	p-value
Mean hospitalization length	6.71 ± 1.33 days	12.33 ± 3.08 days	< 0.001
Surgical site infection	4 (10.26%)	1 (2.56%)	0.17
Mortality	0 (0%)	0 (0%)	--
Pancreatic pseudocyst	0 (0%)	2 (5.13%)	0.15
Recurrent pancreatitis	1 (2.56%)	11 (28.21%)	0.002

Discussion

Gallstones are formed in the gallbladder secondary to the solidification of the bile forming and in majority of the cases remain asymptomatic while approximately 20% of these eventually cause troubling symptoms and complications like pancreatitis (14, 15). Present study focused on an important aspect of management of acute gallstone pancreatitis which is the timing at which the gallstones, that are major etiological factor of pancreatitis (16), should be removed by performing LC. In this instance, two schools of thought exist, one favoring the early conductance of LC while others favoring a delayed LC approach. Present study aimed to compare the outcomes of these two surgical approaches.

In present study, average age of the patients who were admitted with “acute pancreatitis” and were found to have gallstones was approximately forty-three years. It has been reported in previous literature that majority of cases of “gallstones” are in their forties which is similar to what has been reported in present study (17). Majority of the patients who had “gallstones” leading to acute pancreatitis were females. This correlates with the clear female predominance of having “gallstones” being reported in multiple studies as well as printed and published literature (18, 19). It was also observed that majority of patients in present study had their BMI in overweight to obese range which can be explained by a strong association of high BMI and obesity with the occurrence of both “gallstones” and “pancreatitis” (20, 21). To make diagnosis of “gallstones” ultrasound abdomen was used which is the primary as well as highly accurate modality of gallstones diagnosis (22).

In terms of intra-operative parameters, it was observed that “early LC” was associated with significantly shorter operative time ($p < 0.001$). This finding was similar to what has been reported in a study conducted by Chandak et al. (23). On the other hand, Egin et al. (11) reported no significant difference between early and delayed LC in terms of operative time. Additionally, there was significantly less frequency of presence of adhesions in the operative field ($p = 0.01$) and intra-operative bleeding (0.05). However, in terms of frequency of retention of stone in CBD and conversion rate to open procedure, there was no statistically significant difference between early and delayed LC groups ($p > 0.05$). This was similar to the results

reported by Egin et al. (11), Chandak et al. (23) and Riquelme et al. (24).

In terms of hospitalization length, it was observed that patients who underwent “early LC” had significantly shorter hospitalization length as compared to those who underwent “delayed LC” ($p < 0.001$). This finding was similar to the findings of Riquelme et al. (24) and Sharma et al. (25), both of which showed similar trend of hospitalization length. On important factor that has a significant impact on hospitalization length and treatment expenses is nosocomial infection at the surgical site (26). In present study, infection rate was quite low in both study groups and the difference of infection rate was also statistically insignificant ($p = 0.17$). Similarly in terms of frequency of formation of “pancreatic pseudocyst” no statistically significant difference was observed between groups ($p = 0.15$). However, in terms of frequency of recurrent pancreatitis, “early LC” provided significantly better outcome as compared to “delayed LC” ($p = 0.002$). This finding was similar to the results of Egin et al. (11) who reported significantly high frequency of recurrent pancreatitis among gallstone pancreatitis patients who had “delayed LC”. None of the patients admitted with gallstone pancreatitis died in present study. Compared to this, Sharma et al. (25) reported significantly high mortality rates among gallstone pancreatitis patients who had “delayed LC”.

Based on the results of present study it is evident that “early LC” is a better surgical option among patients suffering from gallstone pancreatitis rather than “delayed LC”. Although there is a slight risk of intra-operative complications with it but overall outcomes are significantly better with “early LC” among patients suffering from gallstone pancreatitis.

Conclusion

In conclusion, among patients suffering from gallstone pancreatitis, “early LC” provides significantly better surgical outcomes as compared to “delayed LC”.

Declarations

Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department Concerned.

Consent for publication

Approved

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Conflict of interest

The authors declared absence of conflict of interest.

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Manuscript drafting.

Conception of Study, Development of Research Methodology Design, Study Design, Review of manuscript, final approval of manuscript.

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Manuscript revisions, critical input.

References

- Ingraham, N. E., King, S., Proper, J., Siegel, L., Zolfaghari, E. J., Murray, T. A., Vakayil, V., Sheka, A., Feng, R., Guzman, G., Roy, S. S., Muddappa, D., Usher, M. G., Chipman, J. G., Tignanelli, C. J., & Pendleton, K. M. (2021). Morbidity and mortality trends of pancreatitis: an observational study. *Surgical infections*, 22(10), 1021–1030. <https://doi.org/10.1089/sur.2020.473>.
- Patel, M. L., Shyam, R., Atam, V., Bharti, H., Sachan, R., & Parihar, A. (2022). Clinical profile, etiology, and outcome of acute pancreatitis: Experience at a tertiary care center. *Annals of African medicine*, 21(2), 118–123. https://doi.org/10.4103/aam.aam_83_20.
- Irum, R. & Yousaf, M. (2021). Diagnostic accuracy of ultrasonography in diagnosing acute pancreatitis, taking computed tomography as gold standard. *Journal of Sharif Medical and Dental College*, 7(1), 30–36.
- Sendler, M., & Algül, H. (2021). Pathogenese der akuten Pankreatitis [Pathogenesis of acute pancreatitis]. *Der Internist*, 62(10), 1034–1043. <https://doi.org/10.1007/s00108-021-01158-y>.
- Aggarwal, A., Mathur, A. V., Verma, R. K., Gupta, M. & Raj, D. (2020). Comparison of BISAP and Ranson's score for predicting severe acute pancreatitis and establish the validity of BISAP score. *International Surgery Journal*, 7(5), 1473–1480. <http://doi.org/10.18203/2349-2902.isj20201854>.
- Assakran, B. S., Khalid, R., Albadrani, H., Alsuhaibani, A., Almutairi, A., Alhomidan, R., Alfarhan, G., & Alshaya, R. (2023). Incidence of asymptomatic gallstones in obese patients who underwent bariatric surgery in Qassim Region at King Fahad Specialist Hospital. *Cureus*, 15(8), e44154. <https://doi.org/10.7759/cureus.44154>.
- Khan, I., Yadav, P., Saran, R. K., Sharma, S., & Sharma, A. K. (2023). A study of the degree of gall bladder wall thickness and its impact on patients undergoing laparoscopic cholecystectomy. *Cureus*, 15(5), e38990. <https://doi.org/10.7759/cureus.38990>.
- Akram, M., Arsalan, M., Kumar, V., Ahmed, M., Rizwan, M., Iqbal, W. & Abbas, K. (2022). Outcome of laparoscopic cholecystectomy in acute pancreatitis secondary to gallstones: a prospective observational study from Pakistan. *Liaquat National Journal of Primary Care*, 2022, 4. <https://doi.org/10.37184/lnjpc.2707-3521.4.15>.
- Walayat, S., Baig, M., & Puli, S. R. (2021). Early vs late cholecystectomy in mild gall stone pancreatitis: An updated meta-analysis and review of literature. *World journal of clinical cases*, 9(13), 3038–3047. <https://doi.org/10.12998/wjcc.v9.i13.3038>.
- Randial Pérez, L. J., Fernando Parra, J., & Aldana Dimas, G. (2014). Seguridad de la colecistectomía laparoscópica temprana (<48 h) para pacientes con pancreatitis aguda biliar leve: revisión sistemática de la literatura y metaanálisis [The safety of early laparoscopic cholecystectomy (<48 hours) for patients with mild gallstone pancreatitis: a systematic review of the literature and meta-analysis]. *Cirugia española*, 92(2), 107–113. <https://doi.org/10.1016/j.ciresp.2013.01.024>.
- Eğın, S., Yeşiltaş, M., Gökçek, B., Tezer, H., & Karahan, S. R. (2017). Early laparoscopic cholecystectomy following acute biliary pancreatitis expedites recovery. *Ulusal travma ve acil cerrahi dergisi = Turkish journal of trauma & emergency surgery : TJTES*, 23(6), 495–500. <https://doi.org/10.5505/tjtes.2017.50128>.
- ElSayed, N. A., Aleppo, G., Aroda, V. R., Bannuru, R. R., Brown, F. M., Bruemmer, D., Collins, B. S., Hilliard, M. E., Isaacs, D., Johnson, E. L., Kahan, S., Khunti, K., Leon, J., Lyons, S. K., Perry, M. L., Prahalad, P., Pratley, R. E., Seley, J. J., Stanton, R. C., Gabbay, R. A., ... on behalf of the American Diabetes Association (2023). 2. Classification and diagnosis of diabetes: standards of care in diabetes-2023. *Diabetes care*, 46(Suppl 1), S19–S40. <https://doi.org/10.2337/dc23-S002>.
- Szatmary, P., Grammatikopoulos, T., Cai, W., Huang, W., Mukherjee, R., Halloran, C., Beyer, G., & Sutton, R. (2022). Acute pancreatitis: diagnosis and treatment. *Drugs*, 82(12), 1251–1276. <https://doi.org/10.1007/s40265-022-01766-4>.
- Finch, B. J., Robinson, P. D., & Wakefield, C. H. (2022). What you need to know about gallstone disease. *British journal of hospital medicine (London, England : 2005)*, 83(12), 1–8. <https://doi.org/10.12968/hmed.2022.0351>.
- Kundumadam, S., Fogel, E. L., & Gromski, M. A. (2021). Gallstone pancreatitis: general clinical approach and the role of endoscopic retrograde cholangiopancreatography. *The Korean journal of internal medicine*, 36(1), 25–31. <https://doi.org/10.3904/kjim.2020.537>.
- Isogai M. (2024). Pathophysiology of severe gallstone pancreatitis: A new paradigm. *World journal of gastroenterology*, 30(7), 614–623. <https://doi.org/10.3748/wjg.v30.i7.614>.
- Jadoon, S., Nawaz, M., Javed, S., Imtiaz, H., Jadoon, O., & Taimoor, A. (2021). Study on the prevalence of gallstones in patients undergoing cholecystectomy in Benazir Bhutto Shaheed Hospital (DHQ) Abbottabad. *Journal of Ayub Medical College, Abbottabad*, 33(1), 102–104.

18. Song, Y., Ma, Y., Xie, F. C., Jin, C., Yang, X. B., Yang, X., Long, J. Y., Wang, D. X., Sang, X. T., Li, L. M., Zhao, H. T., & Ning, Y. (2022). Age, gender, geographic and clinical differences for gallstones in China: a nationwide study. *Annals of translational medicine*, 10(13), 735. <https://doi.org/10.21037/atm-21-6186>.
19. Salari, N., Hasheminezhad, R., Heidarisharaf, P., Khaleghi, A. A., Azizi, A. H., Shohaimi, S., & Mohammadi, M. (2023). The global prevalence of gallstones in pregnancy: A systematic review and meta-analysis. *European journal of obstetrics & gynecology and reproductive biology*: X, 19, 100237. <https://doi.org/10.1016/j.eurox.2023.100237>.
20. Parra-Landazury, N. M., Cordova-Gallardo, J., & Méndez-Sánchez, N. (2021). Obesity and gallstones. *Visceral medicine*, 37(5), 394–402. <https://doi.org/10.1159/000515545>.
21. Kuan, L. L., Dennison, A. R., & Garcea, G. (2020). Association of visceral adipose tissue on the incidence and severity of acute pancreatitis: A systematic review. *Pancreatology: official journal of the International Association of Pancreatology (IAP)*, 20(6), 1056–1061. <https://doi.org/10.1016/j.pan.2020.05.027>.
22. Murphy, M. C., Gibney, B., Gillespie, C., Hynes, J., & Bolster, F. (2020). Gallstones top to toe: what the radiologist needs to know. *Insights into imaging*, 11(1), 13. <https://doi.org/10.1186/s13244-019-0825-4>.
23. Chandak, U., Pind, V., Mitra, A., Bansod, P. Y., Gaikwad, U. & Ramteke, P. (2022). Early versus late laparoscopic cholecystectomy in acute biliary pancreatitis: a prospective randomised study. *International Surgery Journal*, 9(9), 1558-1565. <https://doi.org/10.18203/2349-2902.isj20222059>.
24. Riquelme, F., Marinkovic, B., Salazar, M., Martínez, W., Catan, F., Uribe-Echevarría, S., Puelma, F., Muñoz, J., Canals, A., Astudillo, C., & Uribe, M. (2020). Early laparoscopic cholecystectomy reduces hospital stay in mild gallstone pancreatitis. A randomized controlled trial. *HPB : the official journal of the International Hepato Pancreato Biliary Association*, 22(1), 26–33. <https://doi.org/10.1016/j.hpb.2019.05.013>.
25. Sharma, A., Madapu, A., Rakholiya, J., Sharma, S. & Jha, A. (2021). Early versus late laparoscopic cholecystectomy in patients with acute gallstone pancreatitis. *SN Comprehensive Clinical Medicine*, 3, 590–599. <https://doi.org/10.1007/s42399-021-00765-y>.
26. Iqbal, T., Fater, B.B. & Ali, S. (2024). Knowledge, attitude and practice of nurses regarding infection control in operation theater in secondary care hospital. *Menoufia Medical Journal*, 37(2), 5. <https://doi.org/10.59204/2314-6788.3055>.



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