

The Impact Of Age And Gender On Cholelithiasis In Patients With Hypertension: A Retrospective Study

Indra Riris Delima Siregar¹, Gusbakti Rusip², Ica Yulianti Pulungan³

¹Master Programme in Clinical Medicine, Universitas Prima Indonesia, Medan-20118, Indonesia

²Department of Family Medicine, Universitas Prima Indonesia, Medan-20118, Indonesia

³Department of Radiology, Universitas Prima Indonesia, Medan-20118, Indonesia

*E-mail : gusrusip@gmail.com

ABSTRACT

Cholelithiasis and hypertension are prevalent conditions with potentially interrelated pathophysiological mechanisms involving metabolic dysfunction and systemic inflammation. This retrospective observational study investigated the association of age and gender with hypertension stages among adult patients diagnosed with cholelithiasis using non-contrast abdominal CT scans at Royal Prima General Hospital Medan. A total of 133 hypertensive patients meeting inclusion criteria were analyzed, with 27.1% classified as stage I hypertension and 72.9% as stage II. Female patients predominated in both stages (63.9% and 64.9%, respectively), without statistically significant sex differences between stages ($p=0.910$). Age distributions revealed a significant association with hypertension severity: individuals aged 30–44 years mainly presented with stage I hypertension (83.3%), whereas older groups, particularly those 45 years and above, predominantly exhibited stage II hypertension ($p < 0.001$). These findings align with current understanding of vascular aging and the impact of systemic inflammatory pathways exacerbated by comorbid cholelithiasis, which may diminish estrogen's cardiovascular protective effects in females. The study underscores the necessity for early detection and tailored management strategies focusing on aging populations with comorbid conditions to mitigate progression to advanced hypertension stages.

Keywords: *hypertension stages, cholelithiasis, age, gender differences*

INTRODUCTION

Cholelithiasis, characterized by the formation of gallstones within the biliary tract, represents a significant global health burden with substantial clinical and economic implications. Epidemiological data indicate a worldwide prevalence ranging from 10% to 20%, with notable regional and demographic variability influenced by genetic, environmental, and lifestyle factors. Concurrently, hypertension—a leading cause of cardiovascular morbidity and mortality—has emerged as a potential independent risk factor for gallstone formation. Recent studies highlight a bidirectional relationship modulated by age and gender. This association is particularly significant given the shared metabolic pathways underlying both conditions, including dyslipidemia, insulin resistance, and chronic inflammation, which synergistically drive the pathophysiological mechanisms of these diseases (Jones et al., 2024; X. Wang et al., 2022; Zhang et al., 2022).

Large-scale cross-sectional and cohort studies consistently demonstrate a positive correlation between hypertension and gallstone disease. A pivotal study involving 318,403 individuals reported that hypertension significantly increases the risk of gallstones (Odds Ratio [OR] = 1.12; 95% Confidence Interval [CI]: 1.06–1.19), with a dose-response

relationship observed between blood pressure severity and gallstone prevalence. This association exhibits marked demographic heterogeneity: the risk is most pronounced in younger adults (<40 years) and middle-aged adults (40–60 years), diminishing in the elderly population (>60 years). For instance, systolic blood pressure (SBP) correlates positively with the age at first cholecystectomy ($\beta = 0.20$; 95% CI: 0.13–0.26), suggesting that hypertensive stress may accelerate gallstone formation in early adulthood while potentially delaying surgical intervention until later ages (Sun et al., 2009; Zhang et al., 2025; Zhu et al., 2016).

Sex differences further reinforce this relationship. Females exhibit a 1.4 to 1.8-fold higher prevalence of cholelithiasis compared to males, a disparity attributed to hormonal influences on biliary cholesterol metabolism. Estrogen increases hepatic cholesterol uptake and decreases bile acid synthesis, leading to cholesterol-supersaturated bile that facilitates gallstone nucleation. Hypertension exacerbates this risk, with females showing a stronger association between elevated blood pressure and gallstones (OR = 1.19 vs. 1.05 in males). Postmenopausal women experience heightened susceptibility to hypertension-related cholelithiasis due to decreased estrogen levels and increased insulin resistance, underscoring the interplay between hormonal changes and metabolic dysfunction. Conversely, hypertensive males present a distinct risk profile driven by metabolic syndrome components—hypertension, dyslipidemia, and obesity—that cumulatively increase gallstone risk by 33% with each additional metabolic abnormality (K. Wang et al., 2025; W. Yu et al., 2024; Zhang et al., 2022).

The biological nexus between hypertension and cholelithiasis involves shared genetic, metabolic, and inflammatory pathways. Polymorphisms in genes regulating cholesterol transport (ABCG5/8) and steroidogenesis (CYP17A1) have been implicated in both conditions, indicating genetic predispositions contributing to comorbid dysregulation. Insulin resistance—a hallmark of metabolic syndrome—stimulates hepatic cholesterol secretion and reduces bile acid synthesis, thereby promoting cholesterol supersaturation in bile. Moreover, chronic inflammation and oxidative stress associated with hypertension impair gallbladder motility and wall integrity, exacerbating bile stasis and crystal nucleation. Leptin, an adipokine elevated in hypertension, also plays a role by altering bile salt composition, notably reducing hydrophobic bile acids essential for cholesterol solubilization (K. Wang et al., 2025; K. Yu et al., 2017; Zhu et al., 2016).

Despite substantial epidemiological evidence, inconsistencies persist across studies due to variations in diagnostic criteria, population stratification, and confounding factors such as obesity and diabetes. While meta-analyses affirm hypertension as a significant risk factor for cholelithiasis (Relative Risk [RR]: 1.29; 95% CI: 1.22–1.36), the mechanisms underlying age- and sex-specific vulnerability remain incompletely understood. For example, the protective role of estrogen in premenopausal women contrasts with its lithogenic effects under hyperinsulinemic conditions, highlighting the necessity for further targeted demographic research. Additionally, the clinical significance of hypertension in the progression to symptomatic gallstones requiring cholecystectomy warrants clarification, as some studies report no significant association between hypertension and cholecystectomy risk (H. H. Wang et al., 2009; X. Wang et al., 2022; W. Yu et al., 2024; Zhang et al., 2022).

The aim of this study is to investigate the relationship between cholelithiasis (gallstone disease) and the variables of age and gender in adult patients with hypertension,

using abdominal CT-scan imaging at RSU Royal Prima. Specifically, the study seeks to clarify how age and sex influence the prevalence or characteristics of cholelithiasis among hypertensive adults, thereby contributing to a better understanding of the interactions between these factors in this patient population.

METHODS

This study is designed as an analytical observational study with a retrospective approach. Specifically, the research involves observing and analyzing existing data without administering any intervention to the subjects. Data collection will be conducted retrospectively by reviewing patients' medical histories to identify the associations between past exposure to independent variables and the occurrence of cholelithiasis in hypertensive patients, which serves as the dependent variable. The study is carried out at Royal Prima General Hospital, Medan, with data retrieval performed at the medical records department. The entire research process spans three months, from May to July 2025.

The target population of this study comprises all adult patients diagnosed with cholelithiasis and hypertension who underwent non-contrast abdominal CT scans and received treatment at Royal Prima Hospital Medan between May 2024 and May 2025, totaling 200 individuals. From this population, the study sample was selected using purposive sampling. Inclusion criteria comprised patients aged over 18 years who were diagnosed with cholelithiasis and hypertension and had undergone a non-contrast abdominal CT scan. Conversely, exclusion criteria included patients younger than 18 years and those with incomplete medical records. To determine the minimum representative sample size, Slovin's formula was applied with a tolerable margin of error of 5% ($e = 0.05$). Based on this calculation, the final sample size was rounded to 133 patients for use in the study.

The independent variables identified in this study are gender (X1) and age (X2). The dependent variable is the occurrence of cholelithiasis in adult patients with hypertension (Y), diagnosed using non-contrast abdominal CT scan modalities. Gender is defined as the participant's gender identity, measured nominally (male or female) through medical record review. Meanwhile, age is measured on an ordinal scale and categorized into four groups: under 30 years, 30–45 years, 46–60 years, and over 60 years, with data also obtained from medical records. The dependent variable, cholelithiasis with hypertension, is defined as the medical condition characterized by gallstone presence accompanied by persistent elevated blood pressure (hypertension). This variable is measured on an ordinal scale based on CT scan observations from medical records and classified into Grade I and Grade II cholelithiasis with hypertension.

This study utilized secondary data obtained from patient medical records at Royal Prima General Hospital Medan, covering a predetermined time period. Data collection was conducted through systematic observation of the medical record files, supplemented by documentation methods. The primary instrument employed was a checklist-form observation sheet, specifically designed to systematically record relevant information. Additionally, computer software and writing tools were used as supporting instruments for data processing and documentation of findings.

All processed data will be analyzed statistically using SPSS version 26. The Chi-Square test will be employed for this purpose. However, if the assumptions for the Chi-Square test are not met, such as when the expected frequency in any cell of a 2x2 contingency table is less than 5, the alternative Fisher's Exact Test will be used. Statistical significance will be determined based on the p-value, with an association considered significant if $p \leq 0.05$.

RESULTS

This study involved 133 hypertensive patients undergoing abdominal CT scan procedures at Royal Prima General Hospital Medan. All subjects met the inclusion criteria. Table 4.1 presents the characteristics of the study subjects based on hypertension stage among the 133 respondents. The proportion of subjects with stage I hypertension was 36 individuals (27.1%), while those with stage II hypertension numbered 97 individuals (72.9%). Regarding sex distribution, within the stage I hypertension group, there were 13 males (36.1%) and 23 females (63.9%). In the stage II hypertension group, there were 34 males (35.1%) and 63 females (64.9%). There was no significant difference in sex distribution between the two hypertension groups ($P = 0.910$).

Table 1. Chi square test result (n=133)

Variable	Hypertension Stage				p value
	Stage I (n = 36)		Stage II (n = 97)		
	n	%	n	%	
Sex					
Male	13	36.1	34	35.1	0.910
Female	23	63.9	63	64.9	
Age (years)					
<30	6	16.7	0	-	<0.001
30-44	30	83.3	15	15.4	
45-60	0	-	57	58.8	
>60	0	-	25	25.8	

For the age variable, the majority of subjects in the stage I hypertension group were aged 30–44 years (83.3%), whereas in the stage II hypertension group, the age distribution was 15.4% in the 30–44 years range, 58.8% in the 45–60 years range, and 25.8% aged over 60 years. No subjects with stage I hypertension were identified in the age groups ≥ 45 years. A significant difference in age characteristics was observed between the two groups ($P < 0.0001$), with a higher proportion of older individuals in the stage II hypertension group.

DISCUSSION

The results of this study indicate a higher proportion of stage II hypertension (72.9%) compared to stage I hypertension (27.1%) among the population with cholelithiasis. Gender distribution revealed a predominance of females in both hypertension stages (63.9% in stage I and 64.9% in stage II), with no statistically significant difference. These findings are consistent with the study by Defianna et al. (2021) in Sleman, Yogyakarta, which reported hypertension prevalence of 42% among males and 38% among females. However, the results

differ from global data suggesting that males tend to have a higher prevalence of hypertension during young to mid-adulthood (Connelly et al., 2022; Mills et al., 2020).

This discrepancy can be explained by the pathophysiological theory proposed by Gerds et al. (2022), which states that blood pressure regulation in females is influenced by the estrogen hormonal system, providing cardiovascular protective effects prior to menopause. Nevertheless, in populations with comorbidities such as cholelithiasis, these hormonal factors may not confer the same protection due to systemic inflammation and insulin resistance associated with lipid metabolism disorders (Zhang et al., 2025).

The study further demonstrated that all patients with stage I hypertension were aged 30-44 years (83.3%), whereas stage II hypertension was distributed across various age groups, predominantly within the 45-60 years group (58.8%). These findings align with longitudinal research in China, which reported a significant increase in progression from stage I to stage II hypertension with advancing age (Peng et al., 2023). The Framingham study also supports this trend, indicating that 27% of individuals under 60 years exhibit blood pressure readings >140/90 mmHg, compared to 75% in those over 80 years (Nugroho & Erniastutik, 2020).

The underlying pathophysiological mechanisms for these observations can be explained by Buford's (2016) "Vascular Health Triad" concept, which implicates chronic inflammation, oxidative stress, and endothelial dysfunction as common pathways in aging and hypertension development. With advancing age, arterial stiffness increases, the renin-angiotensin-aldosterone system is activated, and nitric oxide production decreases, all contributing to hypertension progression (Nolde et al., 2024).

The predominance of stage II hypertension (72.9%) observed in this study exceeds regional data from Asia. A systematic review in the Asia-Pacific region reported hypertension prevalence ranging from 20% in Taiwan and South Korea to over 40% in Indonesia and Brunei (Loo et al., 2024). Studies in Malaysia documented adolescent hypertension rates of 24.5% in urban areas, whereas in Indonesia, the prevalence among adolescents aged 15-19 years was only 2.6% (Islam et al., 2025).

These differences may be attributable to unique demographic and socioeconomic factors in Asia. Kario et al. (2018) identified that Asian populations tend to have smaller body sizes but relatively larger aortic diameters after adjusting for height and weight, contributing to increased central pulse pressure. Additionally, Asians generally exhibit higher salt sensitivity and favorable responses to renin-angiotensin-aldosterone system inhibitors (Rahman et al., 2024).

The absence of significant gender differences in hypertension stage distribution in this study contrasts with classical theories regarding gender disparities in hypertension. Mills et al. (2020) reported a global hypertension prevalence in 2010 of 31.9% among males and 30.1% among females. However, comorbid conditions such as cholelithiasis may alter these dynamics (Kario et al., 2018; Mills et al., 2020). Supporting this observation is the concept that estrogen exerts protective effects through modulation of the renin-angiotensin system and immune cells, alongside vasoprotective properties. Nonetheless, pathological conditions like cholelithiasis, characterized by chronic inflammation and insulin resistance, may diminish or negate these hormonal protective effects (Goyal et al., 2022; Zhang et al., 2025).

The population with cholelithiasis in this study is characterized by chronic systemic inflammation, which may exacerbate hypertension progression. Evidence suggests that females could exhibit a more pronounced inflammatory response in hypertension due to hormonal regulation and social factors (Cheng et al., 2024). This corresponds to the observed lack of significant gender disparity in hypertension stage distribution among individuals with comorbidities. The underlying pathophysiology involves activation of inflammatory pathways, elevated pro-inflammatory cytokines, increased oxidative stress, and endothelial dysfunction. Chronic inflammation has been shown to accelerate progression from stage I to stage II hypertension by increasing vascular resistance and sympathetic nervous system activation (Buford, 2016).

The predominance of stage II hypertension in this study underscores the necessity for more aggressive intervention strategies in populations with cholelithiasis. Earlier-stage hypertension in younger individuals is associated with up to a 49% increased risk of cardiovascular events in those aged ≤ 50 years (Peng et al., 2023). This highlights the critical importance of early detection and comprehensive management in patients with comorbidities. Evidence-based preventive strategies include multicomponent lifestyle modification, weight control, regular physical activity, and stress management. Lifestyle interventions have been shown to reduce hypertension risk by up to 34.2% in rural populations (Ojangba et al., 2023; Ren et al., 2025).

This study has several strengths that support the validity and relevance of its findings. First, its design, focusing on subject characteristics according to hypertension stages and analyzing demographic variables such as age and sex, provides an in-depth understanding of clinical hypertension distribution in populations with specific comorbidities. Second, clear statistical analyses with explicit reporting of p-values ensure the reliability of between-group comparisons. Moreover, the sample size of 133 respondents is reasonably representative for a local-scale study, providing a foundation for evidence-based policy formulation and targeted interventions. The study's multidimensional comparative approach, linking hypertension findings to cholelithiasis, further enhances its clinical relevance and applicability in health practice.

However, several limitations must be acknowledged. First, the observational and descriptive study design precludes conclusions regarding causality between variables and hypertension progression. Second, the analysis was limited to basic demographic factors without incorporating other potential risk contributors such as socioeconomic status, family history, smoking habits, physical activity patterns, diet, and additional comorbidities. Third, the cross-sectional nature of the study limits assessment of temporal changes or progression of hypertension. Furthermore, generalizability is constrained since the study was conducted at a single site with a population that may have unique characteristics, limiting direct extrapolation of findings to broader populations.

CONCLUSION

This study demonstrated a higher prevalence of stage II hypertension (72.9%) compared to stage I hypertension (27.1%) among hypertensive patients undergoing abdominal CT scans at Royal Prima General Hospital Medan, with no significant gender differences observed between hypertension stages. Age was significantly associated with hypertension

severity, as stage I hypertension predominantly affected individuals aged 30–44 years, while stage II hypertension was more common in older age groups (45 years and above). These findings are consistent with existing literature on the progression of hypertension and highlight the influence of aging and systemic inflammation associated with comorbid cholelithiasis on hypertension severity. The predominance of stage II hypertension in this population underscores the need for early detection and comprehensive management strategies, particularly in patients with comorbidities that may exacerbate disease progression. Despite the study's strengths in detailed demographic analysis and adequate sample size, its cross-sectional and observational design limits causal inference and generalizability. Future research incorporating broader risk factors and longitudinal follow-up is recommended to better elucidate the mechanisms underlying hypertension progression in patients with cholelithiasis and to optimize targeted interventions.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to all the hypertensive patients who participated in this study at Royal Prima General Hospital Medan. We also extend our appreciation to the hospital staff for their support and assistance during the abdominal CT scan procedures and data collection process.

REFERENCES

- Buford, T. W. (2016). Hypertension and aging. *Ageing Research Reviews*, 26, 96–111. <https://doi.org/10.1016/j.arr.2016.01.007>
- Cheng, T., Yu, D., Tang, Q., Qiu, X., Li, G., Zhou, L., Yang, Y., & Wen, Z. (2024). Gender differences in the relationship between the systemic immune-inflammation index and all-cause and cardiovascular mortality among adults with hypertension: evidence from NHANES 1999-2018. *Frontiers in Endocrinology*, 15. <https://doi.org/10.3389/fendo.2024.1436999>
- Connelly, P. J., Currie, G., & Delles, C. (2022). Sex Differences in the Prevalence, Outcomes and Management of Hypertension. *Current Hypertension Reports*, 24(6), 185–192. <https://doi.org/10.1007/s11906-022-01183-8>
- Defianna, S. R., Santosa, A., Probandari, A., & Dewi, F. S. T. (2021). Gender Differences in Prevalence and Risk Factors for Hypertension among Adult Populations: A Cross-Sectional Study in Indonesia. *International Journal of Environmental Research and Public Health*, 18(12), 6259. <https://doi.org/10.3390/ijerph18126259>
- Gerds, E., Sudano, I., Brouwers, S., Borghi, C., Bruno, R. M., Ceconi, C., Cornelissen, V., Diévert, F., Ferrini, M., Kahan, T., Løchen, M.-L., Maas, A. H. E. M., Mahfoud, F., Mihailidou, A. S., Moholdt, T., Parati, G., & de Simone, G. (2022). Sex differences in arterial hypertension. *European Heart Journal*, 43(46), 4777–4788. <https://doi.org/10.1093/eurheartj/ehac470>
- Goyal, P., Chhabra, S. T., & Jyotsna, M. (2022). Hypertension in Women: The Current Understanding and Future Goals. *Indian Journal of Cardiovascular Disease in Women*, 7, 106. https://doi.org/10.25259/mm_ijcdw_476
- Islam, B., Ibrahim, T. I., Tingting, W., Wu, M., & Jiabi, Q. (2025). Current status of elevated blood pressure and hypertension among adolescents in Asia: a systematic review. *Journal of Global Health*, 15, 04115. <https://doi.org/10.7189/jogh.15.04115>
- Jones, M. W., Weir, C. B., & Ghassemzadeh, S. (2024). *Gallstones (Cholelithiasis)*. StatPearls

Publishing.

- Kario, K., Chen, C.-H., Park, S., Park, C.-G., Hoshida, S., Cheng, H.-M., Huang, Q.-F., & Wang, J.-G. (2018). Consensus Document on Improving Hypertension Management in Asian Patients, Taking Into Account Asian Characteristics. *Hypertension*, *71*(3), 375–382. <https://doi.org/10.1161/HYPERTENSIONAHA.117.10238>
- Loo, G., Puar, T., Foo, R., Ong, T. K., Wang, T.-D., Nguyen, Q. N., Chin, C. T., & Chin, C. W. L. (2024). Unique characteristics of Asians with hypertension: what is known and what can be done? *Journal of Hypertension*, *42*(9), 1482–1489. <https://doi.org/10.1097/HJH.0000000000003706>
- Mills, K. T., Stefanescu, A., & He, J. (2020). The global epidemiology of hypertension. *Nature Reviews Nephrology*, *16*(4), 223–237. <https://doi.org/10.1038/s41581-019-0244-2>
- Nolde, J. M., Beaney, T., Carnagarin, R., Stergiou, G. S., Poulter, N. R., Schutte, A. E., & Schlaich, M. P. (2024). Age-Related Blood Pressure Gradients Are Associated With Blood Pressure Control and Global Population Outcomes. *Hypertension*, *81*(10), 2091–2100. <https://doi.org/10.1161/HYPERTENSIONAHA.124.23406>
- Nugroho, A., & Erniastutik. (2020). Determinants of Hypertension Incidence among Middle-aged in Indonesia: A Study of Indonesian Family Life Survey 5 Data. *Pakistan Journal of Medical & Health Sciences*, *14*(2).
- Ojangba, T., Boamah, S., Miao, Y., Guo, X., Fen, Y., Agboyibor, C., Yuan, J., & Dong, W. (2023). Comprehensive effects of lifestyle reform, adherence, and related factors on hypertension control: A review. *The Journal of Clinical Hypertension*, *25*(6), 509–520. <https://doi.org/10.1111/jch.14653>
- Peng, X., Jin, C., Song, Q., Wu, S., & Cai, J. (2023). Stage 1 Hypertension and the 10-Year and Lifetime Risk of Cardiovascular Disease: A Prospective Real-World Study. *Journal of the American Heart Association*, *12*(7). <https://doi.org/10.1161/JAHA.122.028762>
- Rahman, A. R. A., Magno, J. D. A., Cai, J., Han, M., Lee, H.-Y., Nair, T., Narayan, O., Panyapat, J., Van Minh, H., & Khurana, R. (2024). Management of Hypertension in the Asia-Pacific Region: A Structured Review. *American Journal of Cardiovascular Drugs*, *24*(2), 141–170. <https://doi.org/10.1007/s40256-023-00625-1>
- Ren, T., Yuchi, Y., Liao, W., Kang, N., Li, R., & Wang, C. (2025). Healthy lifestyle and its change attenuated the risk of hypertension among rural population: evidence from a prospective cohort study. *Frontiers in Public Health*, *13*. <https://doi.org/10.3389/fpubh.2025.1529570>
- Sun, H., Tang, H., Jiang, S., Zeng, L., Chen, E.-Q., Zhou, T.-Y., & Wang, Y.-J. (2009). Gender and metabolic differences of gallstone diseases. *World Journal of Gastroenterology*, *15*(15), 1886. <https://doi.org/10.3748/wjg.15.1886>
- Wang, H. H., Liu, M., Clegg, D. J., Portincasa, P., & Wang, D. Q.-H. (2009). New insights into the molecular mechanisms underlying effects of estrogen on cholesterol gallstone formation. *Biochimica et Biophysica Acta: Molecular and Cell Biology of Lipids*, *1791*(11), 1037–1047. <https://doi.org/10.1016/j.bbalip.2009.06.006>
- Wang, K., Liu, Z., Tang, R., Sha, Y., Wang, Z., Chen, Y., & Chen, G. (2025). Gallstones in the Era of Metabolic Syndrome: Pathophysiology, Risk Prediction, and Management. *Cureus*, *17*(3). <https://doi.org/10.7759/cureus.80541>
- Wang, X., Hu, F., Lou, Y., Xia, J., Yu, W., Zhang, M., Song, F., Chen, Q., Rui, F., Zhang, C., Cui, P., Kong, L., Zhu, P., Li, G., Mao, M., & Shan, X. (2022). A mini-review of the associations between hypertension and risk of gallstone disease. *Journal of Clinical and Experimental Gastroenterology*, *1*(1), 45–52. <https://doi.org/10.46439/gastro.1.009>
- Yu, K., Zhang, J., Li, Y., Huang, X., Liu, T., Li, C., & Wang, R. (2017). Gallstone disease is associated with arterial stiffness progression. *Hypertension Research*, *40*(1), 31–34. <https://doi.org/10.1038/hr.2016.109>
- Yu, W., Xie, L., Li, S., Lou, Y., Jiang, G., Li, H., Yan, Z., Bai, X., Luo, J., Zhang, C., Li, G., Shan, X., & Wang, X. (2024). Association between hypertension and the risk of gallstone

- disease. *Journal of Clinical Hepatology*, 40(6).
<https://doi.org/http://dx.doi.org/10.12449/JCH240623>
- Zhang, Y., Duan, R., Chen, X., & Wei, L. (2025). Blood pressure, gallstones, and age at first cholecystectomy in U.S. adults: a cross-sectional study. *BMC Gastroenterology*, 25(1), 65. <https://doi.org/10.1186/s12876-025-03641-4>
- Zhang, Y., Sun, L., Wang, X., & Chen, Z. (2022). The association between hypertension and the risk of gallstone disease: a cross-sectional study. *BMC Gastroenterology*, 22(1), 138. <https://doi.org/10.1186/s12876-022-02149-5>
- Zhu, Q., Sun, X., Ji, X., Zhu, L., Xu, J., Wang, C., Zhang, C., Xue, F., & Liu, Y. (2016). The association between gallstones and metabolic syndrome in urban Han Chinese: a longitudinal cohort study. *Scientific Reports*, 6(1), 29937. <https://doi.org/10.1038/srep29937>