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Original Article

Antiplatelet agent for the prevention of late hepatic vascular complications in living donor-dominant liver transplant population

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ABSTRACT

Background: Evidence for the long-term use of antiplatelet drugs to prevent hepatic vascular complications (HVC) is scarce in liver transplantation (LT).
Methods: From national claim data, LT recipients (about 80 % of living donor LT [LDLT]) without graft loss, HVC, or cardiovascular events within 1 year, were classified into those who took antiplatelets for ≥1 year (n = 1744) and for <1 year (n = 1975). Outcomes were compared after the 1-postoperative year index time point.
Results: During a mean follow up of 4.5 years, the risk of graft loss was similar between the groups (aHR 1.16, P = 0.23). However, ≥1-year antiplatelet therapy was associated with a higher risk of graft loss after 3 years (aHR 2.19, P < 0.01). HVC (aHR 0.94, P = 0.87) and major adverse cardiac events (aHR 1.20, P = 0.46) did not correlate with antiplatelet therapy for both groups. In contrast, ≥1-year antiplatelet therapy showed a significantly higher risk of severe bleeding compared to <1-year antiplatelet therapy (aHR 2.24, P < 0.01). This trend was similar in the LDLT subgroup. In our cohort, antiplatelet therapy for ≥1 year did not improve graft survival or HVC; however, it increased the risk of severe bleeding.
Conclusion: We recommend against antiplatelet therapy for more than 1 year in clinically stable LT recipients.

1. Introduction

Liver transplantation (LT) is the optimal treatment option for end-stage liver failure and unresectable liver cancer. The long- and short-term outcomes of liver transplantation have steadily improved over the past 10 years. However, liver graft loss is still approximately 10 % within 1 year and 20 % within 5 years.[1] Causes of liver graft loss include rejection, surgical complications, de novo or recurrent liver diseases, and hepatic vascular complications (HVC).[2] Duffy et al reported that the incidence of hepatic arterial thrombosis was 3%–5% and that of portal vein thrombosis was approximately 2 %, which might result in the deterioration of graft function.[3]

In a Korean single-center study, 37.5 % of LT recipients who experienced hepatic arterial thrombosis died or required re-transplantation, despite hepatic artery revision and vascular intervention.[4] Most cases of HVC reportedly occur within 3–4 weeks after LT; however, Mourad et al reported that hepatic arterial thromboses could even occur up to 10 years after LT.[5]

Although there is no evidence of the benefit of universal thromboprophylaxis, antiplatelet drugs have been widely used for the prevention of HVC after LT. The Spanish Society of Liver Transplantation and the Spanish Society of Thrombosis and Haemostasis guidelines recommend prophylactic administration of aspirin for at least 6 months in high-risk groups, such as those with complex hepatic vascular anastomosis and low arterial flow.[6] In a retrospective study of 838 deceased donor LT (DDLT) recipients, patients receiving antiplatelet therapy showed a lower incidence of hepatic arterial thrombosis than controls (0.4 % vs. 2.2 %), without an increase in drug-related complications such as bleeding.[7]

HVC occurs more frequently in living donor LT (LDLT) recipients using a partial liver graft than in DDLT recipients, which is usually

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performed with a whole liver graft.[8] However, evidence for the prevention of HVC with antiplatelet drugs in the LDLT population is lacking. Furthermore, the long-term use of antiplatelet drugs in LT patients without HVC requires further evaluation. This study aimed to evaluate the risk-benefit of administering antiplatelet drugs for more than 1 year in clinically stable patients using LDLT-dominant national population data.

2. Materials and methods

2.1. Study population

We analyzed the claims data from the National Health Insurance Service (NHIS) of Korea, which covers almost the entire national population. Diagnostic data based on the International Classification of Diseases, Tenth Edition (ICD-10) codes, procedures, and prescriptions at hospital admission and outpatient visits were retrieved from the NHIS database, which has been widely validated in the literature.[9–11]

We enrolled 11,252 patients who underwent LT between January 2006 and December 2016, based on the procedure code (Q8040-Q8050). As depicted in Fig. 1, we compared outcomes between patients who received antiplatelet therapy for more or less than 1 year after LT. Patients aged <18 years at LT (n = 449), had prior solid organ transplantations (n = 59), or used antiplatelet or anticoagulant medications within 6 months before LT (n = 410) were excluded. To compare the outcomes of patients who remained clinically stable until cohort entry, we excluded those who experienced re-LT (n = 435), HVC (n = 796), ischemic stroke (n = 108), coronary revascularization (n = 90), severe bleeding (n = 298), and died (n = 1284) within the first year (Fig. 2). Patients who received antiplatelet administration for less than 180 days within the first year (n = 3188) were excluded to minimize selection bias due to weak intention of thromboprophylaxis regarding HVC risk in individual patients. Additionally, patients who had used anticoagulant (n = 416) within the first year were also excluded. Finally, we included 3719 eligible patients in our analysis.

2.2. Definition for drugs and comorbidities

The use and type of antiplatelet drugs were determined based on the prescription codes, which were classified into aspirin, clopidogrel, and others (Table S1). Each type of antiplatelet drug accounted for more than 50 % of the total prescriptions within 1 year. The discontinuation of antiplatelet therapy was defined as the absence of any prescription code for 180 consecutive days at any given time point. Baseline hepatocellular carcinoma (HCC) was defined as the presence of the diagnostic code C22 within 5 years before LT. Comorbidities of patients were evaluated based on the Charlson Comorbidity Index (CCI),[12] which was calculated using diagnostic codes within 5 years before LT.

2.3. Outcomes

The primary end points of our analysis were graft failure, defined as death or re-LT and HVC, which was identified as hepatic vascular angiography (HA622, HA624, HA721-722, HA725), percutaneous transluminal angioplasty (M6597), hepatic vascular stent insertion (M6605), or angioplasty operation (OA632-633,OA638-639,OB632,OB636-637), except in cases where transarterial chemoembolization (M6644C) for HCC was performed. The secondary endpoints were major adverse cardiovascular events (MACE) and severe bleeding. MACE was defined as cardiovascular death (death on diagnosis of I00-99), nonfatal myocardial infarction (I21-23 with coronary revascularization), and cerebrovascular accident (I60-63). Severe bleeding was defined as gastrointestinal bleeding requiring endoscopic or interventional procedures, accompanied by transfusion or hemorrhagic stroke. More details on the specific codes for the definition of the outcomes are provided in Table S2. Patients were followed-up from 1 year after LT and continued until 5 years thereafter, death, re-LT, or December 31, 2018, whichever came first.

2.4. Statistical analysis

Continuous variables are presented as mean ± standard deviation and compared using Student's t-test. Categorical variables are presented as numbers (proportions) and compared using the chi-square test. For the comparison of outcomes after cohort entry (1 year after LT), the Kaplan–Meier curve analysis was used with the log-rank test. We set a 90-day wash-out period to minimize the effects of other confounders on the outcomes that occurred immediately after cohort entry. The relationship between antiplatelet therapy duration and outcomes was examined using univariate and multivariate Cox analyses. Assessment of the proportional hazards assumptions was confirmed using a kernel-smoothed estimate of the hazard function and log–log survivor plots, and violations were present in analysis for graft failure. Therefore, we performed time dependent Cox regression based on the 3-year point in time where the parallel relationship was not

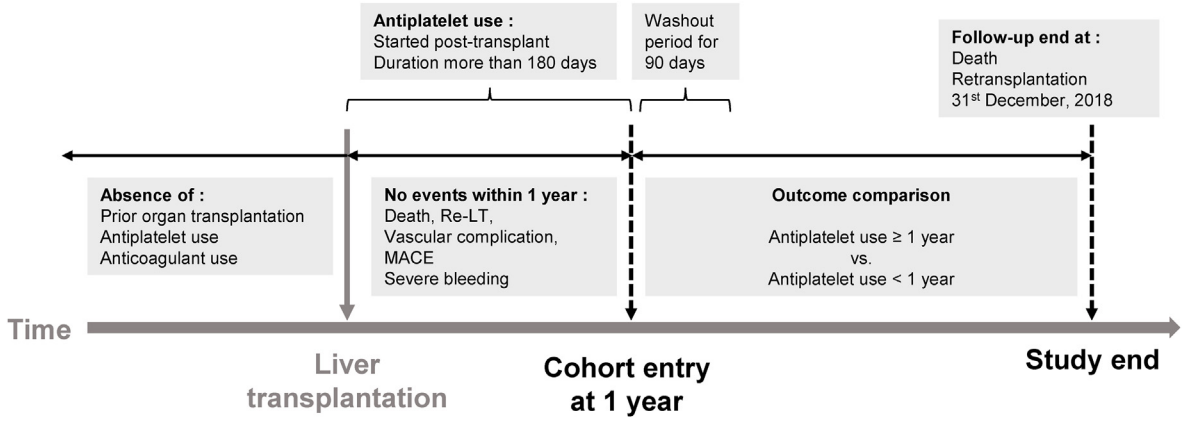

Fig. 1. Study flow
LT, liver transplantation; MACE, major adverse cardiovascular event.

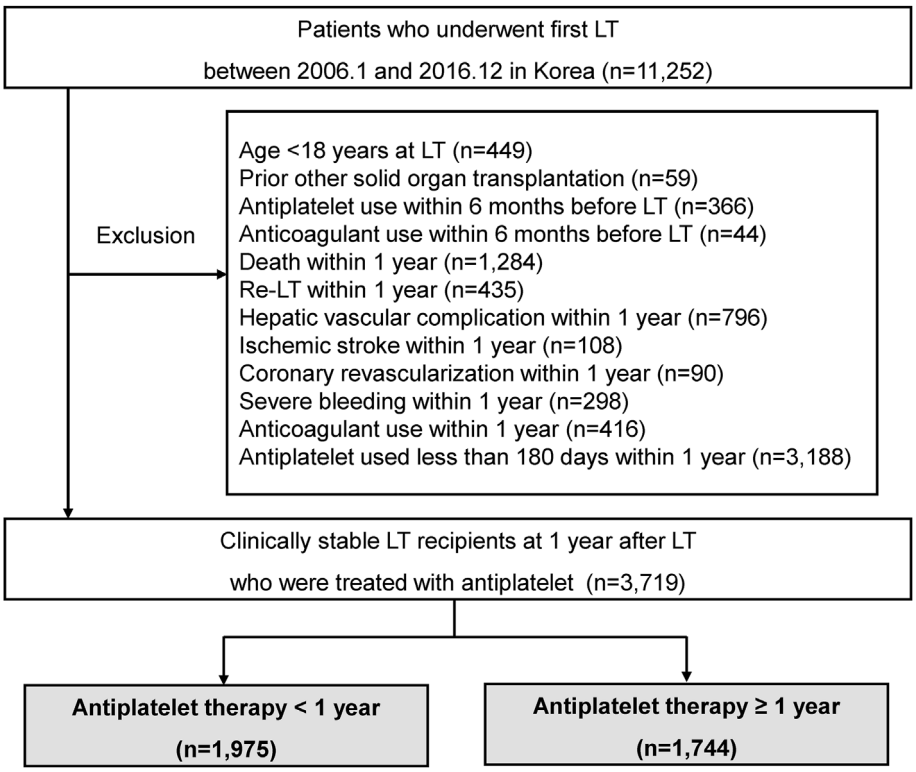

Fig. 2. Study population
LT, liver transplantation.

consistent. Sensitivity analysis was performed in various subgroups according to donor type, HCC, sex, diabetes mellitus, and age (≥60 years). All P-values were two-sided, and P values < 0.05 were considered significant. Analyses were performed using the statistical packages SAS (version 9.4; SAS Institute, Cary, NC, USA) and R version 4.2.0 for Windows (http://cran.r-progect.org/).

2.5. Ethical declaration

This study was approved by the Institutional Review Board (IRB) of the Yonsei University Wonju College of Medicine (Wonju, Korea) (IRB number: CR319308). The requirement of informed consent was waived because anonymous and de-identified information was used for the analyses.

3. Results

3.1. Baseline characteristics

Among the 3719 LT recipients who were clinically stable for one year, 1975 used antiplatelet therapy for less than 1 year, while 1744 used antiplatelet therapy for 1 year or more. Among the patients who received antiplatelet therapy for at least 1 year, the annual rates of antiplatelet use were 80.5 %, 71.1 %, 64.0 %, 57.9 %, and 53.1 % until 5 years after cohort entry (Table S3). The type of antiplatelet agent used was aspirin in 97.0 % of patients and there was no difference between the two groups (Table S4).

As shown in Table 1, Both antiplatelet therapy groups had similar age at LT (53.5 ± 8.6 vs. 52.9 ± 8.7, P = 0.14) and proportion of female sex (26.4 % vs. 26.1 %, P = 0.83). Patients receiving antiplatelet therapy for 1 year or more had a lower proportion of living donor LT (78.7 % vs. 81.7 %, P = 0.02) and HCC (21.7 % vs. 29.4 %, P < 0.001) than those receiving antiplatelet therapy for less than 1 year. Patients receiving antiplatelet therapy for at least 1 year had a low prevalence of congestive heart failure (3.6 % vs. 5.2 %, P < 0.01) and peptic ulcer disease (42.7 % vs. 48.1 %, P < 0.01). However, the CCI (5.6 ± 2.5 vs. 5.5 ± 2.3, P = 0.51) as well as other components were similar between the two groups.

3.2. Outcomes

During a mean follow up of 4.5 (IQR 2.4–5.0) years, a total of 393 deaths occurred. As shown in Fig. 3, the cumulative incidence of graft survival was similar between patients receiving antiplatelet therapy for at least 1 year and those receiving antiplatelet therapy for less than 1 year (3.0 %, 9.0 %, and 13.3 % at 1, 3, and 5 years in patients receiving antiplatelet therapy for at least 1 year vs. 3.2 %, 8.4 %, and 10.4 % at one, three, and five years in patients receiving antiplatelet therapy for less than 1 year, respectively; P = 0.63). HVC (0.1 %, 0.5 %, and 0.8 % vs 0.2 %, 0.5 %, and 0.6 %, P = 0.91) and MACE (0.3 %, 1.7 %, and 3.1 % vs. 0.4 %, 1.4 %, and 2.3 %, P = 0.12). However, patients receiving antiplatelet therapy for at least 1 year showed a higher incidence of severe bleeding than those receiving antiplatelet therapy for less than 1 year (0.6 %, 2.2 %, and 3.6 % vs. 0.3 %, 1.1 %, and 1.5 %, respectively; P < 0.001).

Antiplatelet therapy duration was still not significantly associated with death (HR 1.16, 95 % confidence interval [CI] 0.92–1.41, P = 0.23; Table 2) in multivariable Cox analysis. However, time-dependent Cox analysis showed that antiplatelet therapy for 1 year or more was associated with a higher risk of graft survival 3 years after cohort entry (HR, 2.19 [95 % CI 1.32–3.62], P < 0.01). Antiplatelet administration for both less than and at least 1 year was not significantly associated with HVC (HR 0.94, 95 % CI 0.39–2.21, P = 0.87) or MACE (HR 1.20, 95 % CI 0.75–1.90, P = 0.46). However, antiplatelet for 1 year or more was independently associated with a high incidence of severe bleeding even after adjusting

Table 1
Baseline characteristics.

Variables	Antiplatelet ≥ 1year (n = 1744)	Antiplatelet <1 year (n = 1975)	*P*
Age at LT	53.5 ± 8.6	52.9 ± 8.7	0.14
Sex, female	461 (26.4)	516 (26.1)	0.83
Year of LT			<0.001
2006–2010	299 (17.1)	705 (35.7)	
2011–2014	959 (55.0)	715 (36.2)	
2015–2018	486 (27.9)	555 (28.1)	
Type of LT			0.02
Living	1373 (78.7)	1613 (81.7)	
Deceased	371 (21.3)	362 (18.3)	
Hepatocellular carcinoma	379 (21.7)	581 (29.4)	<0.001
Hypertension	260 (14.9)	326 (16.5)	0.18
Charlson Comorbidity Index	5.6 ± 2.5	5.5 ± 2.3	0.51
Congestive heart failure	62 (3.6)	102 (5.2)	0.02
Peripheral vascular disease	37 (2.1)	54 (2.7)	0.23
Dementia	13 (0.8)	6 (0.3)	0.06
Chronic pulmonary disease	393 (22.5)	407 (20.6)	0.15
Rheumatologic disease	30 (1.7)	48 (2.4)	0.13
Peptic ulcer disease	744 (42.7)	949 (48.1)	<0.01
Diabetes without chronic complication	721 (41.3)	836 (42.3)	0.54
Diabetes with chronic complication	127 (7.3)	172 (8.7)	0.11
Hemiplegia or paraplegia	6 (0.3)	10 (0.5)	0.45
Renal disease	25 (1.4)	40 (2)	0.17
AIDS	3 (0.2)	0 (0)	–

AIDS, acquired immune deficiency syndrome; LT, liver transplantation.

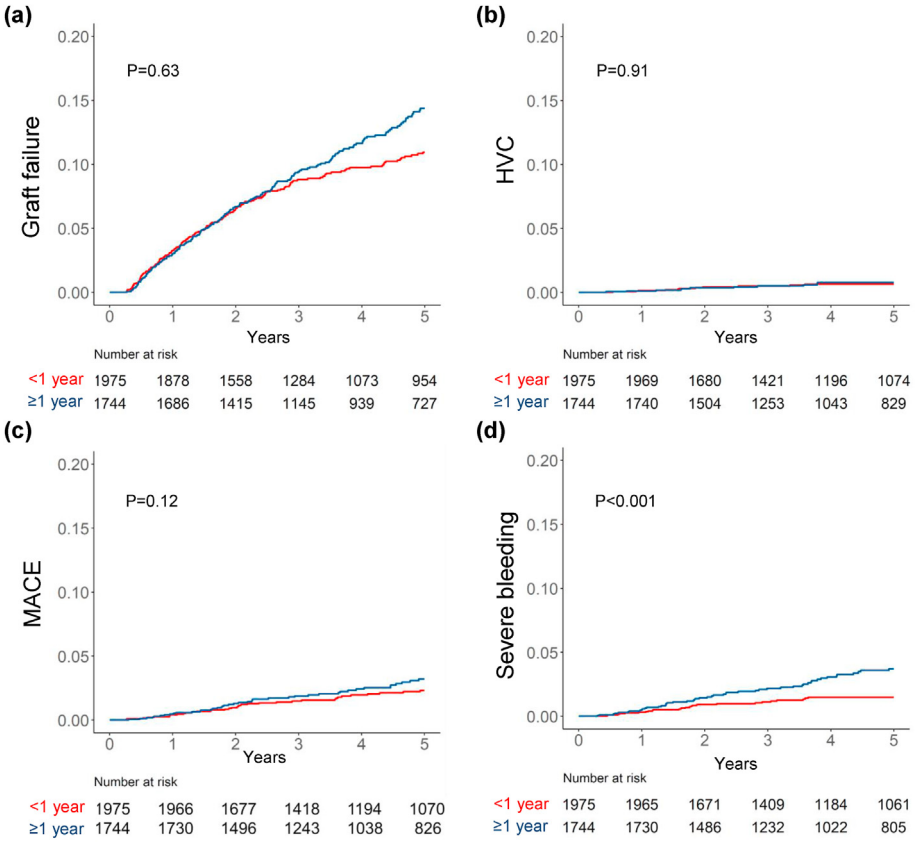

Fig. 3. Kaplan–Meier curves for outcomes
HVC, hepatic vascular complication; MACE, major adverse cardiovascular event.

for covariates (HR 2.24, 95 % CI 1.34–6.64, P < 0.01).

3.3. Subgroup analysis

The association between antiplatelet therapy duration and each outcome was evaluated in the various subgroups (Table 3). Graft survival, HVC, and MACE were not significantly associated with antiplatelet therapy for both less than and at least 1 year. In contrast, antiplatelet therapy for 1 year or more was significantly associated with severe bleeding in subgroups of living donor LT (HR

Table 2
Association between duration of antiplatelet therapy and each outcome since 1 year after LT.

Outcomes	Antiplatelet therapy	Cumulative incidence			Unadjusted		Adjusted	
		1 year	3 years	5 years	HR (95 % CI)	*P*	HR (95 % CI)	*P*
Graft survival	**< 1 year**	3.2	8.4	10.4	Reference		Reference	
	≥ 1 year	3.0	9.0	13.3	1.21 (0.99–1.5)	0.06	1.16 (0.92–1.41)	0.23
HVC	**< 1 year**	0.2	0.5	0.6	Reference		Reference	
	≥ 1 year	0.1	0.5	0.8	1.12 (0.49–2.59)	0.78	0.94 (0.39–2.21)	0.87
MACE	**< 1 year**	0.4	1.4	2.3	Reference		Reference	
	≥ 1 year	0.3	1.7	3.1	1.36 (0.83–2.03)	0.26	1.20 (0.75–1.90)	0.46
Severe bleeding	**< 1 year**	0.3	1.1	1.5	Reference		Reference	
	≥ 1 year	0.6	2.2	3.6	2.38 (1.41–3.67)	<0.01	2.24 (1.34–3.65)	<0.01

HVC, hepatic vascular complication; LT, liver transplantation; MACE, major adverse cardiovascular event.

Table 3
Subgroup analyses.

Subgroup	Graft survival			HVC			MACE			Severe bleeding		
	HR (95 % CI)	P	Interaction P	HR (95 % CI)	P	Interaction P	HR (95 % CI)	P	Interaction P	HR (95 % CI)	P	Interaction P
Type of LT												
Decease (n = 733)	1.11 (0.70–1.77)	0.65	0.99	1.02 (0.09–11.47)	0.99	0.64	1.24 (0.40–3.87)	0.71	0.18	1.02 (0.39–2.68)	0.96	0.20
Living (n = 2986)	1.17 (0.92–1.49)	0.20		0.89 (0.35–2.28)	0.81		1.21 (0.72–2.01)	0.47		2.97 (1.65–5.34)	<0.001	
HCC												
No (n = 2759)	1.09 (0.86–1.39)	0.49	0.70	1.69 (0.49–5.83)	0.41	0.41	0.96 (0.55–1.65)	0.87	0.65	2.33 (1.29–4.20)	0.01	<0.01
Yes (n = 960)	1.54 (0.95–2.48)	0.08		0.43 (0.11–1.70)	0.23		2.32 (0.92–5.88)	0.08		2.11 (0.82–5.45)	0.12	
Sex												
Male (n = 2742)	1.18 (0.93–1.5)	0.17	0.99	1.51 (0.50–4.53)	0.46	0.38	1.40 (0.84–2.33)	0.20	0.39	2.64 (1.49–4.69)	<0.001	0.67
Female (n = 977)	0.97 (0.58–1.61)	0.90		0.36 (0.08–1.55)	0.17		0.50 (0.15–1.61)	0.24		1.21 (0.43–3.45)	0.72	
Diabetes mellitus												
Yes (n = 2431)	0.97 (0.57–1.66)	0.91	0.25	1.66 (0.09–29.76)	0.73	0.72	1.68 (0.69–4.04)	0.25	0.56	3.27 (1.07–9.97)	0.04	<0.001
No (n = 1288)	1.16 (0.92–1.46)	0.22		0.87 (0.35–2.15)	0.77		1.06 (0.62–1.83)	0.83		2.01 (1.15–3.5)	0.01	
Age group												
≥60 (n = 796)	0.89 (0.60–1.32)	0.56	0.99	–	–	0.64	0.58 (0.23–1.47)	0.25	0.18	2.03 (0.76–5.45)	0.16	0.20
<60 (n = 2923)	1.24 (0.96–1.6)	0.10		0.77 (0.31–1.90)	0.57		1.58 (0.91–2.74)	0.11		2.34 (1.31–4.18)	<0.01	

HCC, hepatocellular carcinoma; HVC, hepatic vascular complication; LT, liver transplantation; MACE, major adverse cardiovascular event.

2.97, 95 % CI 1.34–6.64, P < 0.001) and age <60 years (HR 2.34, 95 % CI 1.31–4.18, P < 0.01). Interaction analysis showed that risk of severe bleeding from antiplatelet therapy for 1 year or more was higher in the no HCC group (HR 2.33, 95 % CI 1.29–4.20, P < 0.01) than in the HCC group (HR 2.11, 95 % CI 0.82–5.45, P = 0.124, interaction P < 0.01) and also higher in the diabetes mellitus (DM) group (HR 3.27, 95 % CI 1.07–9.97, P = 0.04) than in the no DM group (HR 2.01, 95 % CI 1.15–3.5, P = 0.12, interaction P < 0.001).

4. Discussion

This study evaluated the benefits of long-term antiplatelet therapy in clinically stable LT patients using a nationwide Korean cohort. We found that antiplatelet therapy for 1 year or more showed no benefit on graft survival, HVC, or MACE when compared with antiplatelet therapy for less than 1 year. In contrast, antiplatelet therapy for 1 year or more showed higher rates of severe bleeding and even higher graft survival after 3 consecutive years than antiplatelet therapy for less than 1 year. This trend was similar in the LDLT subgroups, and the increase in severe bleeding from antiplatelet therapy at 1 year or more was more prominent in patients with DM and those who received LT from non-HCC causes. We recommend against antiplatelet therapy for more than 1 year in clinically stable LT recipients.

Patients with end-stage liver disease are hypocoagulable due to thrombocytopenia, hypofibrinogenemia, and prothrombin time prolongation; however, they are also characterized by rebalanced hemostasis due to changes in procoagulant factors, such as increased von Willebrand factor and factor III and decreased ADAMTS-13 levels and antithrombin.[13] During LT, patients are hypocoagulable not only from preexisting coagulation factor alterations but also from intraoperative heparinization. However, they also show hypercoagulable features from a rebalanced hemostatic state that could continue for at least 30 days.[14] International guidelines recommend prophylactic antiplatelet or anticoagulant therapy for more than 6 months after LT, especially when the risk of HVC is high, although the level of evidence is low.[6] However, the optimal duration of antiplatelet therapy for the prevention of HVC in clinically stable LT recipients has not yet been investigated. This is the first study to reveal that antiplatelet therapy for more than 1 year after LT only increases the risk of severe bleeding and does not benefit graft survival or the prevention of HVC when there are no major complications.

Previous studies have focused on early hepatic artery thrombosis occurring within 1 month after LT in terms of the thromboprophylactic effect of antiplatelet therapy.[7,15] Although reports about late HVC are scarce, few studies on the DDLT population have reported that the incidence of late hepatic artery thrombosis occurring after 1 month of LT was 1.7–4.8 % and could even occur after 5–10 years.[5,16] Although LDLT reportedly has a higher incidence of HVC than DDLT, the incidence of long-term HVC and the effects of thromboprophylaxis have not been studied in the LDLT population.[4,8] The fact that approximately 46.9 % of our population maintained antiplatelet therapy for more than 1 year despite no complications might represent a concern for long-term HVC in the LDLT-predominant population. However, the incidence of long-term HVC occurring after 1 year was 0.6–0.8 %, regardless of antiplatelet therapy, and this was similar in the LDLT subgroup. Thus,

we suggest antiplatelet therapy for no more than 1 year after both LDLT and DDLT, unless there is no HVC or other indications such as cardiovascular disease.

Antiplatelet drugs are essential for secondary prevention of cardiovascular disease.[17] However, routine administration for primary prevention is not recommended due to the increased bleeding risk, which outweighs the benefits of cardiovascular disease prevention.[18] In our LT population, who did not experience any cardiovascular events between 1 year before and after LT, antiplatelet therapy did not appear to be effective in reducing MACE. We suggest against maintaining antiplatelet therapy to prevent cardiovascular diseases.

In the subgroup analysis conducted in this study, the risk of severe bleeding from antiplatelet therapy was significantly higher in LT recipients without HCC than in those with HCC. We assumed that the difference was due to the high bleeding tendency from the cirrhotic status before LT and the remaining splenomegaly after LT, which would contribute to a higher bleeding risk in the non-HCC subgroup. This has not been researched in the literature. Additionally, long-term antiplatelet therapy showed no benefit in terms of survival or MACE; however, the risk of bleeding was higher in patients with DM than in those without DM. A large-scale randomized trial showed that primary prevention with antiplatelet therapy lowered major cardiovascular events in patients with DM; however, this benefit was largely counterbalanced by an increased risk of severe bleeding, such as gastrointestinal and cerebral hemorrhages.[19] Based on these results, we suggest that patients who received LT for liver cirrhosis rather than HCC and are diagnosed with DM should avoid more than 1 year of antiplatelet administration unless there is a definite indication.

Despite the rigorous exclusion of major events related to LT or cardiovascular disease within 1 year, a possible selection bias was a limitation of this population-based study. In addition, the optimal duration of antiplatelet therapy within 1 year of LT should be further evaluated in future studies. Due to the nature of the claims data, we could not distinguish the exact type of HVC. Finally, the lack of detailed surgical and medical risk factors for HVC is another limitation.

Despite these limitations, this is the first and largest study to investigate the risks and benefits of long-term antiplatelet therapy for the prevention of HVC in LT recipients. Antiplatelet administration for 1 year or more showed no benefit in terms of graft survival, HVC, or MACE, but significantly increased the risk of severe bleeding compared to less than 1 year of use. This trend was similar in the LDLT subgroup, and the risk of bleeding from antiplatelet therapy was higher in the non-HCC and DM subgroups. Antiplatelet therapy should not be maintained for more than 1 year in clinically stable LT recipients.

Author contributions

D-GK had full access to all aspects of the study and took responsibility for the integrity of the data and the accuracy of the data analysis.

LGL and D-GK participated in the research design; JYL and SHK participated in the performance of the research; D-GK and JYL participated in the data acquisition; SHK participated in the statistical analysis; D-GK and JYL participated in the writing of the paper; JYL and JGL supervised the study process.

All authors have read and agreed to the published version of the manuscript.

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Declaration of competing interest

The authors declare no conflicts of interest.

Acknowledgements

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.asjsur.2024.04.002.

References

1. Kwong A, Kim WR, Lake JR, et al. OPTN/SRTR 2018 annual data report: liver. *Am J Transplant*. 2020;20(Suppl s1):193–299.
2. Neuberger JM, Bechstein WO, Kuypers DR, et al. Practical recommendations for long-term management of modifiable risks in kidney and liver transplant recipients: a guidance report and clinical checklist by the consensus on managing modifiable risk in transplantation (COMMIT) group. *Transplantation*. 2017;101(4S Suppl 2):S1–S56.
3. Duffy JP, Hong JC, Farmer DG, et al. Vascular complications of orthotopic liver transplantation: experience in more than 4,200 patients. *J Am Coll Surg*. 2009;208(5):896–903. ; discussion 903-895.
4. Choi HJ, Kim DG, Kim Y, et al. Clinical course of hepatic artery thrombosis after living donor liver transplantation using the right lobe. *Liver Transplant*. 2018;24(11):1554–1560.
5. Mourad MM, Liossis C, Gunson BK, et al. Etiology and management of hepatic artery thrombosis after adult liver transplantation. *Liver Transplant*. 2014;20(6):713–723.
6. Montalvá E, Rodríguez-Perálvarez M, Blasi A, et al. Consensus statement on hemostatic management, anticoagulation, and antiplatelet therapy in liver transplantation. *Transplantation*. 2022.
7. Vivarelli M, La Barba G, Cucchetti A, et al. Can antiplatelet prophylaxis reduce the incidence of hepatic artery thrombosis after liver transplantation? *Liver Transplant*. 2007;13(5):651–654.
8. Samstein B, Smith AR, Freise CE, et al. Complications and their resolution in recipients of deceased and living donor liver transplants: findings from the A2ALL cohort study. *Am J Transplant*. 2016;16(2):594–602.
9. Lee J, Lee JS, Park SH, Shin SA, Kim K. Cohort profile: the national Health insurance service-national sample cohort (NHIS-NSC), South Korea. *Int J Epidemiol*. 2017;46(2):e15.
10. Shin DW, Cho B, Guallar E. Korean national Health insurance database. *JAMA Intern Med*. 2016;176(1):138.
11. Cheol Seong S, Kim YY, Khang YH, et al. Data resource profile: the national Health information database of the national Health insurance Service in South Korea. *Int J Epidemiol*. 2017;46(3):799–800.
12. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chron Dis*. 1987;40(5):373–383.
13. Lisman T, Hernandez-Gea V, Magnusson M, et al. The concept of rebalanced hemostasis in patients with liver disease: communication from the ISTH SSC working group on hemostatic management of patients with liver disease. *J Thromb Haemostasis*. 2021;19(4):1116–1122.
14. Werner MJM, de Meijer VE, Adelmeijer J, et al. Evidence for a rebalanced hemostatic system in pediatric liver transplantation: a prospective cohort study. *Am J Transplant*. 2020;20(5):1384–1392.
15. Shay R, Taber D, Pilch N, et al. Early aspirin therapy may reduce hepatic artery thrombosis in liver transplantation. *Transplant Proc*. 2013;45(1):330–334.
16. Gunsar F, Rolando N, Pastacaldi S, et al. Late hepatic artery thrombosis after orthotopic liver transplantation. *Liver Transplant*. 2003;9(6):605–611.
17. Jacobsen AP, Raber I, McCarthy CP, et al. Lifelong aspirin for all in the secondary prevention of chronic coronary syndrome: still sacrosanct or is reappraisal warranted? *Circulation*. 2020;142(16):1579–1590.
18. Arnett DK, Blumenthal RS, Albert MA, et al. ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American College of cardiology/American heart association task force on clinical practice guidelines. *Circulation*. 2019;140(11):e596–e646, 2019.
19. Bowman L, Mafham M, Wallendszus K, et al. Effects of aspirin for primary prevention in persons with diabetes mellitus. *N Engl J Med*. 2018;379(16):1529–1539.