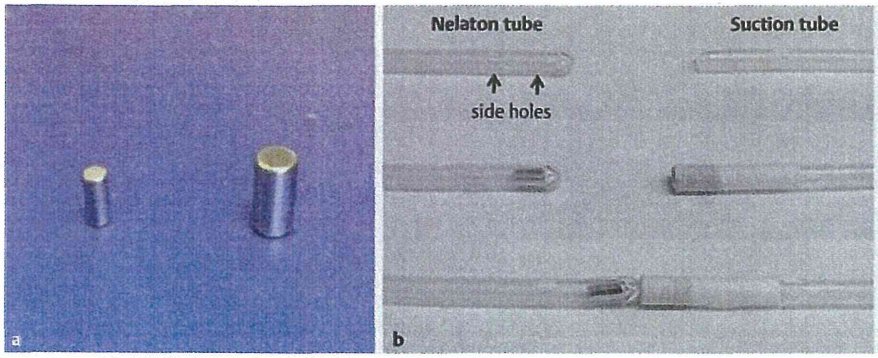

Fig. 1 Positioning of nasobiliary tube for endoscopic nasobiliary drainage (ENBD) using magnet-loaded catheters. **a** On the left is the "daughter" magnet (450 mT; 3 mm diameter, 7 mm length), and the right is the "parent" magnet (530 mT; 5 mm diameter, 10 mm length). **b** The daughter magnet is placed inside the tip of a Nelaton tube. The parent magnet is attached to the tip of a 14-Fr suction tube.

Table 1 Positioning of nasobiliary tube for endoscopic nasobiliary drainage (ENBD) using magnet-loaded catheters. Patient characteristics and results.

Patient no.	Gender; age; years	Diagnosis	Time, seconds	Emetic reflex, n	X-ray exposure, seconds
1	M; 75	Choledocholithiasis	79	0	52
2	M; 74	Cholangiocellular carcinoma	28	0	22
3	M; 80	Cholangitis	22	0	15
4	M; 76	Lymph node metastasis	30	0	25
5	M; 78	Gallbladder cancer	42	0	39
6	M; 41	Gallbladder cancer	34	0	30
7	F; 72	Gallbladder cancer	25	0	12
8	M; 49	Intrahepatic cholangiocarcinoma	40	3	40
9	M; 54	Intrahepatic cholangiocarcinoma	23	1	14
10	M; 73	Klatskin tumor	70	0	58
11	F; 55	Klatskin tumor	36	2	20
12	F; 55	Klatskin tumor	14	0	14
13	M; 53	Pancreatic cancer	37	0	32
14	M; 61	Pancreatic cancer	27	0	27
15	M; 75	Pancreatic cancer	31	0	31
16	M; 80	Pancreatic cancer	40	0	30
17	F; 72	Pancreatic cancer	40	0	40
18	M; 68	Pancreatic cancer	23	1	16
19	M; 69	Pancreatic cancer	18	0	9
20	F; 58	Post liver transplantation	73	2	66

Magnet technique

This method requires a "parent" magnet and a "daughter" magnet (**Fig. 1a**). The neodymium (Nd2Fe14B) rare-earth "daughter" magnet (450 mT; 3 mm diameter, 7 mm length) was placed inside the tip of the Nelaton tube through the side hole; the end hole was sealed to prevent the loss of the magnet. The "parent" magnet (neodymium rare-earth; 530 mT; 5 mm diameter, 10 mm length) was attached to the tip of a 14-Fr suction tube (**Fig. 1b**).

With the patient under sedation and having a mouthpiece fitted, the Nelaton tube with the daughter magnet was inserted through a nostril to the pharynx. Then the suction tube with the parent magnet was inserted through the mouthpiece. This attracted the daughter magnet in the Nelaton tube. The Nelaton tube was led out of the mouth (**Fig. 2**, **Video 1**).

Video 1

Placement of nasobiliary tube using magnet-loaded catheters. The Nelaton tube with a magnet is inserted through the nostril. The suction tube with a magnet is inserted through the mouth. The two magnets attract each other. Then the suction tube is led back out of the mouth with the Nelaton tube attached. The procedure was easy because of the good visibility of magnets under X-ray fluoroscopy. There was no emetic reflex movement during this procedure.

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Evaluation of the method

We evaluated the time for the procedure, measuring from the moment of insertion of the Nelaton tube into the nostril to when the Nelaton tube was led out of the mouth. We recorded the X-ray exposure, and the number of times the emetic reflex was induced. We also assessed complications.

Results

A total of 20 patients were consecutively enrolled between December 2011 and June 2012. The clinical features of all patients are presented in **Table 1**.

The results are also shown in **Table 1**. The procedures were successful in all cases and in no case was a change in operator to a senior doctor required. The mean time for the procedure was 36.6 seconds (range 14–79). The mean number of times the emetic reflex was induced was 0.5 (0–3). The mean X-ray exposure time was 29.6 seconds (9–66). Patients undergoing the magnet method reported no memory of the procedure and no discomfort during the procedure, nor was there any pharyngeal

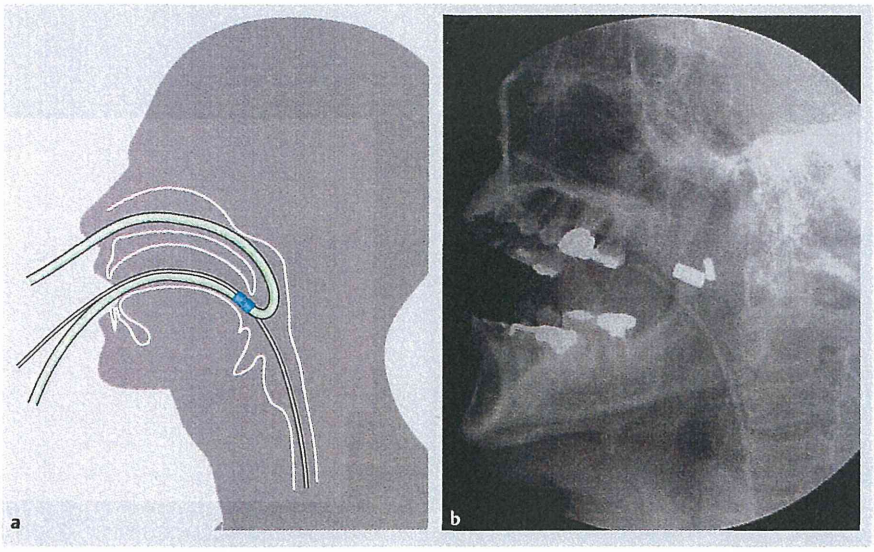

Fig. 2 Placement of nasobiliary tube using magnet-loaded catheters. **a** The Nelaton tube with the "daughter" magnet has been inserted through the nostril. The suction tube with the "parent" magnet has been inserted through the mouth. The two magnets attract each other. The suction tube is led back out of the mouth with the Nelaton tube attached. **b** X-ray image.

pain 2 hours later. There were no complications using the magnet method.

Discussion

In this prospective study, the magnet method was an excellent technique for repositioning the ENBD catheter through the nose. This method was superior in terms of feasibility, safety, and visibility, allowed placement in a shorter time and was less invasive than conventional methods. Even trainees were able to carry out this maneuver safely and reliably. The parts of the device are simple, available and cheap, and preparing the equipment is easy and takes only a few minutes. Thus, there is a definite possibility that the magnet method could become the first choice in ENBD.

The only concern was that the magnets could fall away from the tube. In the future, we need to develop a catheter in which the magnet is completely embedded.

Several techniques using magnets in the digestive system have been previously reported [12, 13]. These have mentioned a magnetic effect upon pacemakers and have stated that although the magnet is powerful, most of its effects can be ignored at a distance of 15 cm from the magnet [14]. We excluded pacemaker patients in this study as a precaution.

Our study had several limitations. First, it included a relatively small number of patients, and secondly, it was a single-center study. Consequently, further multicenter studies will be required to assess this new method.

In conclusion, the magnet method was found to be a superior method for leading the ENBD catheter to the nose, with regard to time required, success rate, and safety. Therefore, the magnet method is a better first-line choice than the conventional techniques. Additionally, although the methods for repositioning the ENBD tube are not directly involved in the treatment, the difficulty of this step has been one of the reasons that physicians and patients avoid ENBD. Taking into account the magnet method and, thus, the reduction in the complexity of ENBD and in the pain for patients, we hope that physicians will reconsider the use of ENBD.

Competing interests: None

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LIPIDS IN HEALTH AND DISEASE

RESEARCH Open Access

Critical role of leukotriene B_4 receptor signaling in mouse 3T3-L1 preadipocyte differentiation

Kae Hirata[1,2*], Koichiro Wada[2], Yuka Murata[1,2], Atsushi Nakajima[3], Takashi Yamashiro[1] and Yoshinori Kamisaki[2]

Abstract

Background: Various inflammatory mediators related to obesity might be closely related to insulin resistance. Leukotrienes (LTs) are involved in inflammatory reactions. However, there are few reports regarding the role of LTs in adipocyte differentiation. Therefore, we investigated the role of leukotriene B_4 (LTB_4)-leukotriene receptor (BLT) signaling in mouse 3T3-L1 fibroblastic preadipocyte differentiation to mature adipocytes.

Methods: Mouse 3T3-L1 preadipocytes were treated with lipoxygenase (LOX) inhibitors, BLT antagonist, and small interfering RNA (siRNA) for BLT1 and BLT2 to block the LTB_4-BLT signaling pathway, then the adipocyte differentiation such as lipid accumulation and the increase in triglyceride was evaluated.

Results: Blockade of BLT signaling by treatment with a LOX inhibitor or a BLT antagonist suppressed preadipocyte differentiation into mature adipocytes. In addition, knockdown of BLT1 and BLT2 by siRNAs dramatically inhibited differentiation. These results indicate the LTB_4-BLT signaling pathway may positively regulate preadipocyte differentiation and be a rate-limiting system to control adipocyte differentiation.

Conclusions: The LTB_4-BLT signaling pathway provides a potent regulatory signal that accelerates the differentiation of mouse 3T3-L1 preadipocytes. Further investigations are necessary to confirm the exact role of LTB_4 and BLTs signaling pathways in preadipocyte differentiation.

Keywords: Leukotrienes, Preadipocyte differentiation, Mouse 3T3-L1 fibroblasts, BLT, siRNA

Background

Diabetes mellitus, hyperlipidemia, hypertension, and atherosclerosis have recently been defined as typical life style-related diseases. A common background of these diseases is obesity, which is thought to cause insulin resistance resulting in the onset of disease [1,2]. Recently, the incidence of obesity and associated metabolic syndrome has dramatically increased. Although high caloric western-style foods are believed to be the main cause of this dramatic increase, other possible risk factors could exist. The involvement of various inflammatory mediators such as tumor necrosis factor alpha (TNFα) and interleukin 6 (IL-6) on obesity might be closely related to insulin resistance [1-4]. One of the most important organs in obesity and insulin resistance are the adipose tissues, as adipocytes generate adipocytokines that are important in the onset of metabolic syndrome [1,2,5].

Leukotrienes (LTs) such as leukotriene B_4, C_4, and D_4 (LTB_4, LTC_4, and LTD_4, respectively) are generated through lipoxygenase (LOX) pathways and induce inflammatory and allergic reactions such as leukocyte activation, capillary permeability, and bronchial contraction [6,7]. LTB_4 binds to specific receptors, BLT1 and BLT2, to activate signaling pathways [8,9]. LTs have been reported to be involved in the proliferation of epithelial, endothelial and mesangial cells [10,11]. In addition, we previously reported that LTB_4 controls immature neural stem cell proliferation and differentiation via the BLT signaling pathway [12]. Thus, LTB_4 and its signaling pathway might be involved in cell proliferation and differentiation. However, there have been few reports regarding the role of LTs in adipocyte differentiation.

In this study, we investigated the role of LTB_4 and BLTs signaling pathways in preadipocyte differentiation

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in a mouse fibroblastic 3T3-L1 cell line, a widely used cell line for research of preadipocyte differentiation [13]. We analyzed the effects of LOX inhibitors, a BLT antagonist and BLTs-specific siRNAs on the differentiation of 3T3-L1 to clarify the function of BLTs on preadipocyte differentiation. Our results suggest a potentially important and novel role for LTB_4 and BLT functions on preadipocyte differentiation.

Results

Effects of LOX inhibitors and BLT antagonist on mouse 3T3-L1 preadipocyte differentiation

Mouse 3T3-L1 cells can differentiate from fibroblastic cells into mature adipocytes in induction medium for differentiation containing insulin (INS), dexamethasone (DEX), 3-isobutyl-1-methylxanthine (IBMX) and rosiglitazone (ROSI), a specific ligand for peroxisome proliferator-activated receptor gamma (PPARγ) [13,14]. We used these induction conditions for the differentiation of mouse 3T3-L1 preadipocytes (Figure 1). Nordihydroguaiaretic acid (NDGA), a pan-LOX inhibitor, inhibited the accumulation of lipids, the decrease of triacylglycerol (TG) contents and the index of mouse 3T3-L1 preadipocyte differentiation into mature adipocytes (Figure 2A). No alterations in cell proliferation were observed under our experimental conditions (data not shown). AA-861, a 5-LOX inhibitor, also inhibited the differentiation of mouse 3T3-L1 preadipocytes into mature adipocytes (Figure 2B). These suppressive effects occurred in a concentration-dependent manner. In addition, ONO-4057, a specific LTB_4 receptor antagonist, suppressed mouse 3T3-L1 preadipocyte differentiation (Figure 2C). These results suggest that the LTB_4-BLT signaling pathway may be involved in preadipocyte differentiation.

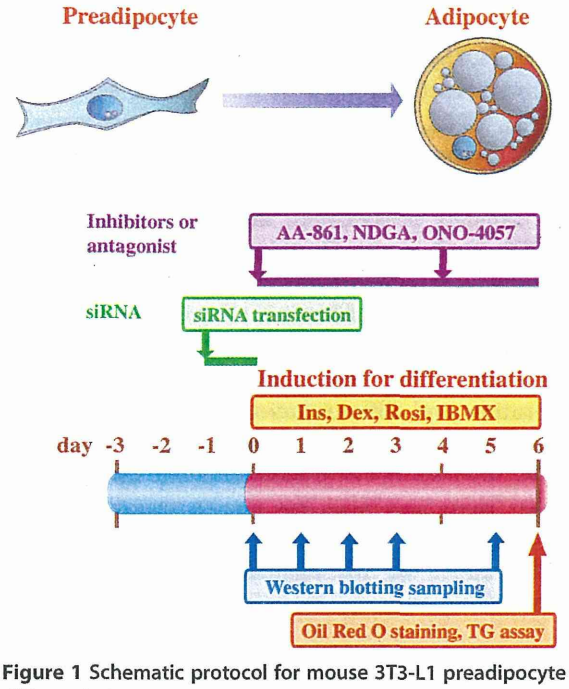

Figure 1 Schematic protocol for mouse 3T3-L1 preadipocyte differentiation.

Effect of BLT1 and BLT2 knockdown by siRNA on mouse 3T3-L1 preadipocyte differentiation

To investigate whether BLTs are expressed on preadipocytes, we performed western blot analysis, which showed that both BLT1 and BLT2 were expressed in mouse 3T3-L1 preadipocytes from the start to late phases of differentiation (Figure 3). In addition, the level of LTB_4 secreted from preadipocytes into the culture medium was 31.8 ± 8.4 nmol/L (mean ± SEM, n=3). These results indicate that the BLT-signaling pathway induces the differentiation of preadipocytes to mature adipocytes.

Therefore, we designed siRNAs specific for BLT1 or BLT2 to knockdown receptor expression. siRNAs against BLT1 and BLT2 successfully suppressed the expression of BLT1 and BLT2 (Figure 4A). Indicators of preadipocyte differentiation such as lipid accumulation and TG contents were decreased by BLT1 siRNA (Figure 4B and C). Similar results were observed with BLT2 siRNA (Figure 4D and E). These results clearly indicated that the LTB_4-BLT signaling pathway accelerates mouse 3T3-L1 preadipocyte differentiation, and blockade or knockdown of BLTs leads to the suppression of preadipocyte differentiation.

Combination knockdown of BLT1 and BLT2 by siRNA on mouse 3T3-L1 preadipocyte differentiation

To clarify the role of each receptor, BLT1 and BLT2, on adipocyte differentiation, we performed combination treatment of BLT1-siRNA and BLT2-siRNA. The combined treatment of BLT1-siRNA (12.5 nM) and BLT2-siRNA (12.5 nM) remarkably decreased lipid accumulation and TG contents in comparison to single knockdown (Figure 5A and B) indicating that combination knockdown of BLT1 and BLT2 by specific siRNA efficiently suppressed preadipocyte differentiation.

Discussion

The mouse fibroblastic 3T3-L1 cell line established by Green is widely used for the investigation of adipocyte differentiation [13,15,16]. The involvement of various molecules for adipocyte differentiation has been investigated using this cell line. However, it is not fully understood whether inflammation-related lipid mediators, such as LTs and prostaglandins (PGs), promote or inhibit the onset of metabolic syndrome. Several previous reports indicated that PGD_2-derived 15-deoxy-$\Delta^{12,14}$-PGJ_2 promoted

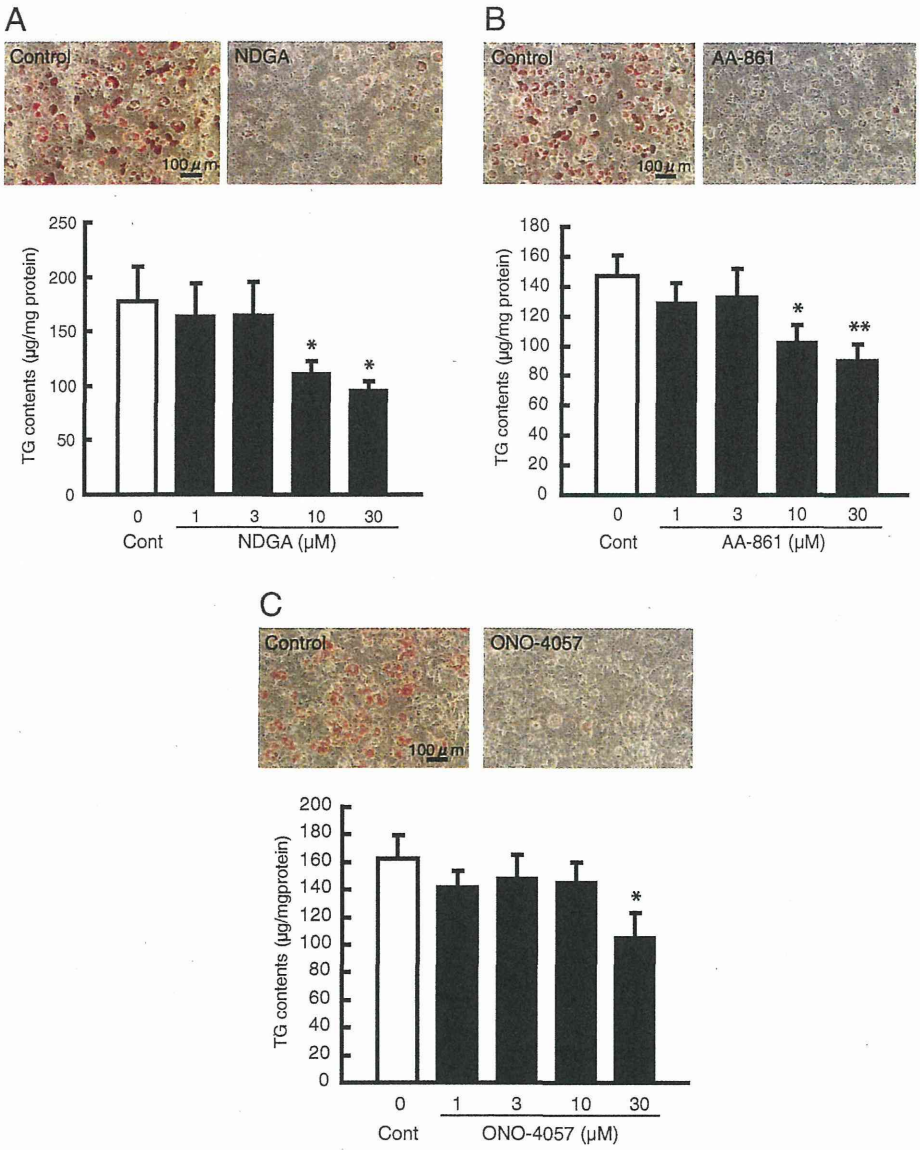

Figure 2 Effects of LOX inhibitors and the BLT antagonist on mouse 3T3-L1 preadipocyte differentiation. (A), **(B)** and **(C)**: Effects of NDGA **(**LOX inhibitor, **A)**, AA-861 **(**5-LOX inhibitor, **B)**, or ONO-4057 **(**a specific BLT antagonist, **C)** on lipid accumulation in mouse 3T3-L1 preadipocytes. Mouse 3T3-L1 preadipocytes were treated with NDGA, AA-861 or ONO-4057 for 6 days. Then, accumulation of triacylglycerol (TG), a marker of lipid accumulation (bottom panel), in matured adipocytes was measured and expressed as TG contents (μg/mg protein). Each column represents the mean ± SEM from 4-8 independent experiments. **P*<0.05, ***P*<0.01 vs. vehicle control. Upper left panel shows representative photographs of differentiated mouse 3T3-L1 preadipocytes treated with vehicle for 6 days. Upper right panel shows representative photographs of undifferentiated mouse 3T3-L1 preadipocytes treated with NDGA, AA-861 or ONO-4057 for 6 days. Cells were stained with Oil Red O method to visualize lipid accumulation. Scale bar represents 100 μm.

adipocyte differentiation via activation of the PPARγ pathway [17,18]. Therefore, cyclooxygenase-related prostanoids are considered involved in the enhancement of adipocyte differentiation. In contrast, there have been few reports regarding the involvement of LOX-related metabolites in adipocyte differentiation.

In this study, 5-LOX inhibitors and a specific LTB_4 receptor antagonist inhibited the differentiation of mouse 3T3-L1 preadipocytes into mature adipocytes. Furthermore, BLT1 and BLT2 knockdown by siRNA suppressed mouse 3T3-L1 preadipocyte differentiation. In addition, combination knockdown of BLT1 and BLT2 by siRNA on mouse 3T3-L1 preadipocytes remarkably decreased lipid accumulation and TG contents in comparison to single knockdown alone. These results clearly indicate that the LTB_4-BLT signaling pathway is involved

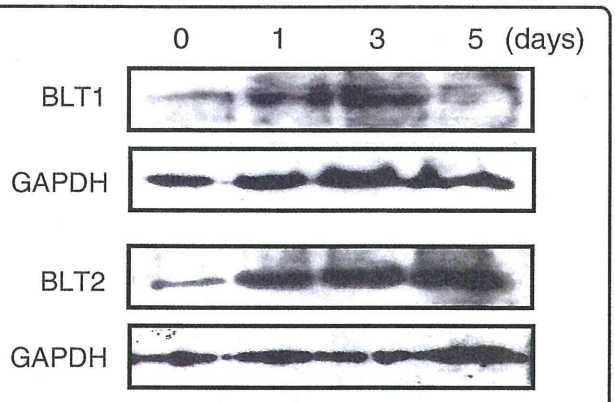

Figure 3 Expression of BLT1 and BLT2 during preadipocyte differentiation. Detection of BLT1 and BLT2 was performed by western blot analysis using anti-BLT1 or -BLT2 antibodies. GAPDH was used as an internal standard for confirmation of equally applied amounts of protein.

in mouse 3T3-L1 preadipocyte differentiation, and blockade or knockdown of BLTs leads to the suppression of preadipocyte differentiation.

Furthermore, we demonstrated that both LTB_4 receptors, BLT1 and BLT2, were expressed in mouse 3T3-L1 preadipocytes. We also confirmed the release of LTB_4 from preadipocytes into the culture medium. These results indicate that a paracrine or autocrine pathway of BLT-signaling operates in preadipocytes, for the positive regulation of mouse 3T3-L1 preadipocyte differentiation from adipocyte progenitors, because inhibition of this pathway with LOX inhibitors, a BLT antagonist, or siRNAs for BLTs induced the inhibition of preadipocyte differentiation.

Interestingly, a recent paper showed that deletion of BLT1 protected mice from high-fat diet-induced insulin resistance [19]. Such observations clearly show that BLT1 signaling is closely involved in insulin resistance. However, the results of a BLT1 knockout mouse study were considered to be due to systemic mechanisms. Therefore, the local action of BLT1 signaling on adipose tissues should be investigated. Our present data using 3T3-L1 adipocytes may partly support these previous observations. To clarify the issue, an adipocyte specific BLT1-conditional knockout mouse study is required. The involvement of BLT1 signaling may be important for adipocyte differentiation and related systemic disorders such as insulin resistance and obesity.

To investigate the potential mechanisms of BLT signaling-mediated acceleration of 3T3-L1 preadipocyte differentiation, we performed DNA microarray analysis to identify the molecules regulated by LTB_4-BLT signaling. Many molecules were significantly altered by treatment with a 5-LOX inhibitor, AA-861 or a specific BLT antagonist, ONO-4057 (unpublished data). Among them, we initially focused on the expressions of PPARγ and CCAAT-enhancer-binding protein, alpha (C/EBPα) which is known as important key transcriptional regulators to control adipocyte differentiation. However, both molecules did not show significant changes at the microarray analysis. Namely, increase in PPARγ expression was from 0.9 to 1.3-fold, that in C/EBPα expression was from 0.7 to 1.1-fold, respectively. Therefore, it is expected that LTB_4-BLT signaling pathway promoted 3T3-L1 preadipocyte differentiation via other molecules independent to PPARγ or C/EBPα. Further investigations will be required to clarify the molecules.

In conclusion, the LTB_4-BLT signaling pathway provides a potent regulatory signal that accelerates the differentiation of mouse 3T3-L1 preadipocytes. Our results imply a potentially important and novel role for LTB_4 and BLT functions on preadipocyte differentiation. Further investigations are necessary to confirm the exact role of LTB_4 and BLTs signaling pathways in preadipocyte differentiation.

Material and methods

Reagents and antibodies

INS, DEX and IBMX were purchased from Sigma Japan (Tokyo, Japan). ROSI was purchased from GlaxoSmith Kline K. K. (Tokyo, Japan). LT synthetase, LOX inhibitor, NDGA, and 5-LOX specific inhibitor, AA-861, were purchased from Sigma Japan. ONO-4057, a specific BLT antagonist, was a kind gift from ONO Pharmaceutical Co. Ltd. (Osaka, Japan). Anti-BLT1 and -BLT2 polyclonal antibodies were purchased from Cayman Chemicals (Ann Arbor, MI, USA).

Cell culture and induction of adipocyte differentiation

Mouse 3T3-L1 preadipocytes have been frequently used to study the differentiation of preadipocytes in vitro. Cell culture and induction of differentiation of preadipocytes were performed according to the previously described method (Figure 1) [14,20]. Briefly, mouse 3T3-L1 preadipocytes were cultured in Dulbecco's modified Eagle's medium (DMEM, Sigma Japan) supplemented with 10% fetal bovine serum, 1% MEM non-essential amino acids, 100 IU/mL penicillin and 0.1 mg/mL streptomycin. At 3 days after reaching confluency (day 0), the medium was replaced with induction medium for differentiation containing INS (150 nM), DEX (1 μM), IBMX (100 μM) and ROSI (PPARγ-ligand, 1 μM). The differentiation medium was changed every 4 days until analysis (day 6).

The LOX inhibitor (NDGA/AA-861) or specific BLT antagonist (ONO-4057) was prepared in dimethyl sulfoxide (DMSO, Sigma Japan) and added to the differentiation medium from day 0 to day 6 (Figure 1). The DMSO concentration was maintained up to 0.1% of

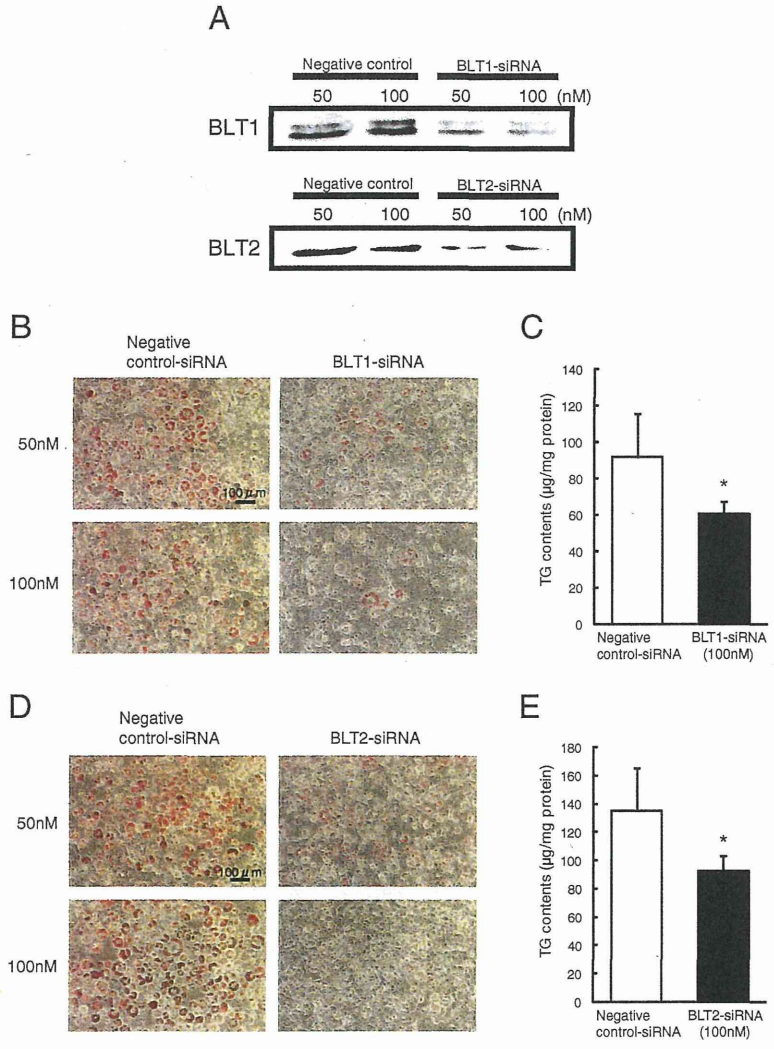

Figure 4 Effect of BLT1 and BLT2 knockdown by siRNA on mouse 3T3-L1 preadipocyte differentiation. (A): Confirmation of BLT1 and BLT2 knockdown by specific siRNAs. Negative control is cells treated with negative control siRNA (Stealth RNAi Negative Control Duplexes). **(B)** and **(C)**: Effect of BLT1 knockdown by siRNA. Representative microscopic **(B)** images of differentiated mouse 3T3-L1 adipocytes by Oil Red O staining. Scale bar represents 100 μm. **(C)**: Accumulation of TG in mature adipocytes was measured and expressed as TG contents (μg/mg protein). Each column represents the mean ± SEM from 3-5 independent experiments. *$P<0.05$ vs. negative control-siRNA treatment. **(D)** and **(E)**: Effect of BLT2 knockdown by siRNA. Representative microscopic **(D)** images of differentiated mouse 3T3-L1 adipocytes by Oil Red O staining. Scale bar represents 100 μm. **(E)**: Accumulation of TG in mature adipocytes was measured and expressed as TG contents (μg/mg protein).

the total volume, and preliminary experiments demonstrated no significant effects of 0.1% DMSO on cell differentiation.

Evaluation of adipocyte differentiation

Differentiation of preadipocytes to mature adipocytes was visually monitored by microscopic observation after Oil red O staining [14,15]. In addition, the amount of triglyceride, an index of lipid accumulation, was quantitatively measured using a Triglyceride E-test Wako kit (Wako Pure Chemicals, Tokyo, Japan). The amount of triglyceride was normalized by protein amount and expressed as TG contents (μg/mg protein).

siRNA for knockdown of BLT1 and BLT2

We designed small interfering RNA (siRNA) for knockdown of BLT1 and BLT2 using an siRNA system (Qiagen, Tokyo, Japan). The sequences of the sense and antisense strand for BLT1 used were 5'-CAACCUACAC UUCCUAUUA-3', and 5'-UAAUAGGAAGUGUAGGU UG-3', respectively. The sequences of the sense and antisense strand for BLT2 used were 5'-GGGACUUA

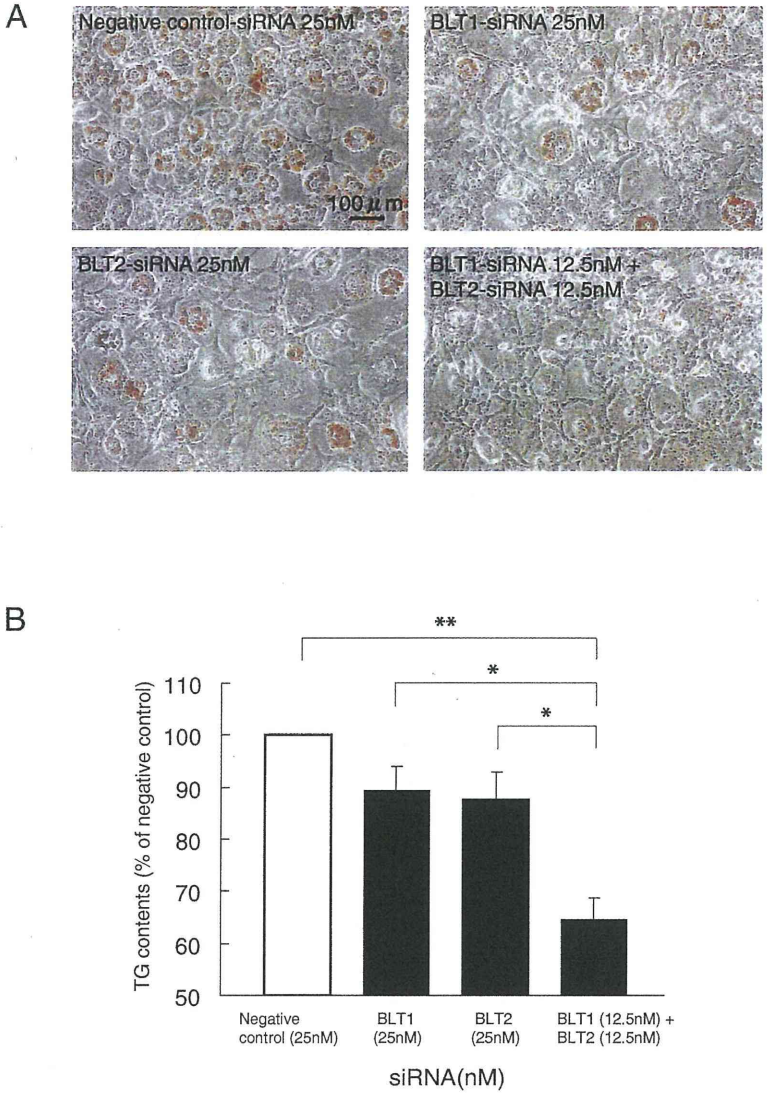

Figure 5 Combination knockdown of BLT1 and BLT2 by siRNA on mouse 3T3-L1 preadipocyte differentiation. Mouse 3T3-L1 preadipocytes were treated with a combination of BLT1-siRNA (12.5 nM) and BLT2-siRNA (12.5 nM). **(A)**: Representative microscopic images of differentiated mouse 3T3-L1 adipocytes by Oil Red O staining. Scale bar represents 100 μm. **(B)**: Accumulation of TG in mature adipocytes was measured and expressed as TG contents (% of negative control). Each column represents the mean ± SEM from 3 independent experiments. *P<0.05, **P<0.01 vs. negative control-siRNA treatment.

ACAUACUCUUA-3', and 5'-UAAGAGUAUGUUAAG UCCG-3', respectively.

For transfection, siRNAs or negative control siRNA (Stealth RNAi Negative Control Duplexes, Invitrogen, Tokyo, Japan) were combined with Lipofectamine RNAiMAX (Invitrogen) and incubated for 20 minutes at room temperature to produce the transfection mixture. Then, the transfection mixture was added to preadipocytes at a final concentration of 25, 50 and 100 nM siRNA (Figure 1). At 24 hours after the start of transfection, the medium was replaced with differentiation medium to induce differentiation. Samples were collected at days 1, 2, 3 and 5 day for western blot analysis, and at day 6 for TG assay and Oil red O staining.

Statistical analysis

Results were expressed as the mean ± SEM. Statistical comparisons were performed using the Student's t-test or Tukey's method after analysis of variance (ANOVA). The results were considered significantly different at P <0.05.

Abbreviations

LT: Leukotriene; LOX: Lipoxygenase; siRNA: Small interfering RNA; TNFα: Tumor necrosis factor alpha; IL-6: Interleukin 6; INS: Insulin;

DEX: Dexamethasone; IBMX: 3-Isobutyl-methylxanthine; ROSI: Rosiglitazone; PPARγ: Peroxisome proliferator-activated receptor gamma; NDGA: Nordihydroguaiaretic acid; TG: Triacylglycerol; PG: Prostaglandin; C/EBPα: CCAAT-enhancer-binding protein, alpha; DMEM: Dulbecco's modified Eagle's medium; DMSO: Dimethyl sulfoxide; ANOVA: Analysis of variance.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
KH performed all experiments and statistical analysis, discussion of results and drafted the manuscript. KW conceived the study, participated in discussion of the results, provided additional funding for the study. YM assisted in performance of some experiments. AN, YK, TY participated in discussion of the results. All authors read and approved the final manuscript.

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ORIGINAL ARTICLE—LIVER, PANCREAS, AND BILIARY TRACT

The association of insomnia with gastroesophageal reflux symptoms in biopsy-proven nonalcoholic fatty liver disease

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Abstract
Background It is suggested that nonalcoholic fatty liver disease (NAFLD), including nonalcoholic fatty liver (NAFL) and nonalcoholic steatohepatitis (NASH), can be associated with insomnia and gastro-esophageal reflux disease (GERD). The relationship between GERD and insomnia in subjects with biopsy-proven NAFLD was investigated.
Methods This study enrolled 123 patients with biopsy-proven NAFLD. Insomnia was assessed by the Athens Insomnia Scale (AIS), a self-assessment psychometric instrument designed to quantify sleep difficulty based on ICD-10 criteria; AIS scores ≥ 6 were considered positive for insomnia. GERD symptoms were evaluated using a frequency scale for the symptoms of GERD (FSSG); FSSG scores ≥ 8 were considered positive. Logistic regression models were used to evaluate the association of insomnia with GERD, after adjusting for potential confounders. Thirteen patients with GERD were treated with the proton pump inhibitor rabeprazole (RPZ; 10 mg/day), for 12 weeks.
Results Of the 123 patients, 76 (62 %) were female and 87 (71 %) were obese, with 34 (28 %) having AIS scores ≥ 6 and 31 (25 %) having FSSG scores ≥ 8. Liver biopsy revealed that 40 patients (33 %) had NAFL and 83 (67 %) had NASH. FSSG and AIS scores were similar in the two groups. HOMA-IR, FSSG scores and γGT (GGT) concentrations were significantly higher in insomniacs than in non-insomniacs. Logistic regression analysis demonstrated that FSSG score and GGT concentration were independently associated with insomnia. RPZ treatment resulted in significantly reductions in both AIS and FSSG scores.
Conclusions Nearly 30 % of patients with biopsy-proven NAFLD had insomnia, which was related to GGT and GERD and could be relieved by RPZ treatment.

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