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ORIGINAL RESEARCH

RETRACTED ARTICLE: Antitumor effect of triptolide in T-cell lymphoblastic lymphoma by inhibiting cell viability, invasion, and epithelial–mesenchymal transition via regulating the PI3K/AKT/mTOR pathway

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Introduction: T-cell lymphoblastic lymphoma (T-LBL) is a widely disseminated disease worldwide. Triptolide (TPL) is purified from Chinese herb and displays anti-inflammatory, anti-fertility, anti-tumor and immunosuppressive effects.

Materials and methods: Here, in vitro and in vivo experiments were conducted to investigate the anti-tumor effect of TPL treatment in T-LBL and the potential mechanism in T-LBL progression.

Results: TPL inhibited cell proliferation of T-LBL cells (Jurkat cells and Molt-3 cells) in a dose-dependent manner. Flow cytometry analysis showed that cell apoptosis rate was increased by TPL treatment. TPL also up-regulated the expression of Caspase-3, Bax and down-regulated the expression of Bcl-2, indicating that TPL promoted apoptosis in Jurkat cells. Moreover, TPL inhibited invasion ability of Jurkat cells and down-regulated the expression of MMP-3 and MMP-9 in dose-dependent manner. The expression of Snail, Slug, Twist and Integrin αVβ6 was decreased and the expression of E-cadherin was increased by TPL treatment, indicating that TPL inhibited EMT of Jurkat cells. Apart from that, TPL treatment attenuated the phoslevels of PI3K, Akt and mTOR and suppressed AKT activation compared with control group, suggesting that TPL inhibited PI3K/Akt/mTOR signal pathway in T-LBL. In vivo experiments showed that TPL inhibited tumor growth of T-LBL and promoted apoptosis of tumor cells. The expression of PCNA, Bcl-2, Snail, p-PI3K, p-Akt and mTOR was suppressed by TPL in a dose-dependent manner, suggesting that TPL suppressed tumor growth and promoted apoptosis of tumor cells by inhibiting PI3K/Akt/mTOR signal pathway in T-LBL.

Conclusion: In conclusion, TPL exerted anti-tumor effect in T-LBL by inhibiting cell viability, invasion and EMT via regulating the PI3K/AKT/mTOR pathway.

Keywords: triptolide, T-cell lymphoblastic lymphoma, invasion, EMT, PI3K/AKT/mTOR

Introduction

Lymphoblastic lymphoma (LBL) is a rare, aggressive neoplasm of precursor lymphoblast origin. B-cell LBL accounts for 10% of LBL. T-cell lymphoblastic lymphoma (T-LBL) accounts for 90% of LBL and occurs mostly in children and adolescents, with a male predominance.[1] T-LBL is a widely disseminated disease, and it often presents as a mediastinal bulky mass with pleural and pericardial effusion through clinical examination.[2] Central nervous system (CNS) involvement is seen in 5%–10% of T-LBL patients.[3] T-LBL is a chemotherapy-sensitive disease with a 75%–85% event-free survival rate using current treatment regiments. However, 5-year overall survival is still poor for T-LBL mainly due to relapse, often as a result of spread to CNS.[4] Thus, suppressing

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the viability and invasion ability of T-LBL tumor cells can ameliorate T-LBL and improve prognosis of patients.

Triptolide (TPL), a diterpenoid triepoxide, is purified from the roots of Chinese herb *Tripterygium wilfordii*.[5] TPL is widely used to treat autoimmune disorders including rheumatoid arthritis and systemic lupus erythematosus.[6] TPL displays a broad-spectrum bioactivity profile including anti-inflammatory, antifertility, antitumor, and immunosuppressive effects.[7] TPL has been reported to inhibit proliferation and promote apoptosis of various tumor cells including pancreatic cancer, breast cancer, and gastric cancer in vitro and in vivo.[8] Banerjee's[9] study indicated that TPL affected *O*-GlcNAc modification of Sp1 and prevented translocation of Sp1 to the nucleus, thus inducing apoptosis of pancreatic tumor cells. Huang[10] also reported that TPL inhibited proliferation of prostate cancer cells by suppressing the expression of SUMO-specific protease 1. In addition, TPL is also reported to exert antimetastatic effect by downregulating the level of multiple cytokine receptors in colon cancer cells.[11] However, it has not been examined whether TPL can affect apoptosis and invasion of T-LBL tumor cells, and so further investigations are urgently needed.

The mechanism of TPL treatment has been investigated in various diseases. A previous study reported that TPL inhibited NF-κB and AP-1 transcriptional activity to induce apoptosis and inhibit cell proliferation in gastric cancer cells.[12] Zhu[13] also reported that TPL functioned as an effective apoptotic inducer in a p53-independent but NF-κB-dependent mechanism, thus providing promising agent for tumor types with p53 mutation/deletion. Kim's[14] study revealed that TPL combined with BIIB021 exerted synergistic cytotoxicity in thyroid carcinoma cells through suppressing PI3K/Akt/mTOR and NF-κB signal pathways. However, the mechanism of TPL treatment in T-LBL is not yet thoroughly understood.

The primary aim of this study is to investigate the effect of TPL treatment in T-LBL and the potential mechanism. Our study found that TPL inhibited cells viability, invasion, and epithelial–mesenchymal transition (EMT) to inhibit T-LBL progression. These results indicated that TPL was possibly used as an effective therapeutic agent for treatment of T-LBL.

Materials and methods

Cell culture and TPL treatment methods

Jurkat and Molt-3 cell lines were purchased from ATCC and were cultured in Roswell Park Memorial Institute-1640 medium (Thermo Fisher Scientific, Waltham, MA, USA) supplemented with 10% heat-inactivated fetal calf serum (Thermo Fisher Scientific). All cell lines were kept under sterile conditions at 37°C with 5% CO_2.

TPL ($C_{20}H_{24}O_6$, molecular weight 360.4 g/mol, Figure 1A) was purchased from Sigma Chemical Company (St Louis, MO, USA) and was initially dissolved in dimethyl sulfoxide. TPL was diluted to various concentrations with serum-free culture medium.

Cell proliferation assay

MTT assay was used to detect cell proliferation. Cells were seeded into 96-well plates at the concentration of 4×10^4 cells/well in triplicate for each group. Different concentrations of TPL were added, and the final concentrations were 0, 10, 20, 40, 60, 80, 100, 200, and 300 nM in different groups, respectively. MTT bought from Janssen Pharmaceuticals, Inc (New Brunswick, NJ, USA) was added in each well (5 mg/mL) at 24 and 48 hours and incubated in dark at 37°C for 2 hours. Absorbance was determined at a wavelength of 570 nm.

Flow cytometric analysis

Jurkat cells were seeded into six-well plates and treated with control (dimethyl sulfoxide) or TPL (20, 60, or 80 nM) for 24 hours, respectively. Annexin V-FITC/propidium iodide (PI) apoptosis detection kit (Multisciences, Shanghai, People's Republic of China) was used for apoptosis analysis. Briefly, 2×10^5 cells were washed with phosphate-buffered saline (PBS) and then resuspended in 500 µL of 1× binding buffer. Then 5 µL of Annexin V-FIFC and 10 µL of PI were added to the suspension. The cells were detected using a Beckman–Coulter system (EPICS Altra II; Beckman-Coulter, Fullerton, CA, USA).

Western blot

Proteins were extracted from cells using radioimmunoprecipitation assay lysis buffer (Beyotime Institute of Biotechnology, Jiangsu, People's Republic of China). The cell lysates were centrifuged at 12,000 rpm for 15 minutes at 4°C. The supernatants were collected and transferred into new tubes, and the concentrations were measured using the Bio-Rad protein assay kit (Beijing Solarbio Science & Technology Co., Ltd., Beijing, People's Republic of China) according to the manufacturer's instructions. Total proteins were separated by sodium dodecyl sulfate–polyacrylamide gel electrophoresis and then transferred to polyvinylidene difluoride membranes (Bio-Rad Laboratories, Inc., Hercules, CA, USA). The membranes were blocked with 5% skim milk, followed by incubation with primary antibodies overnight

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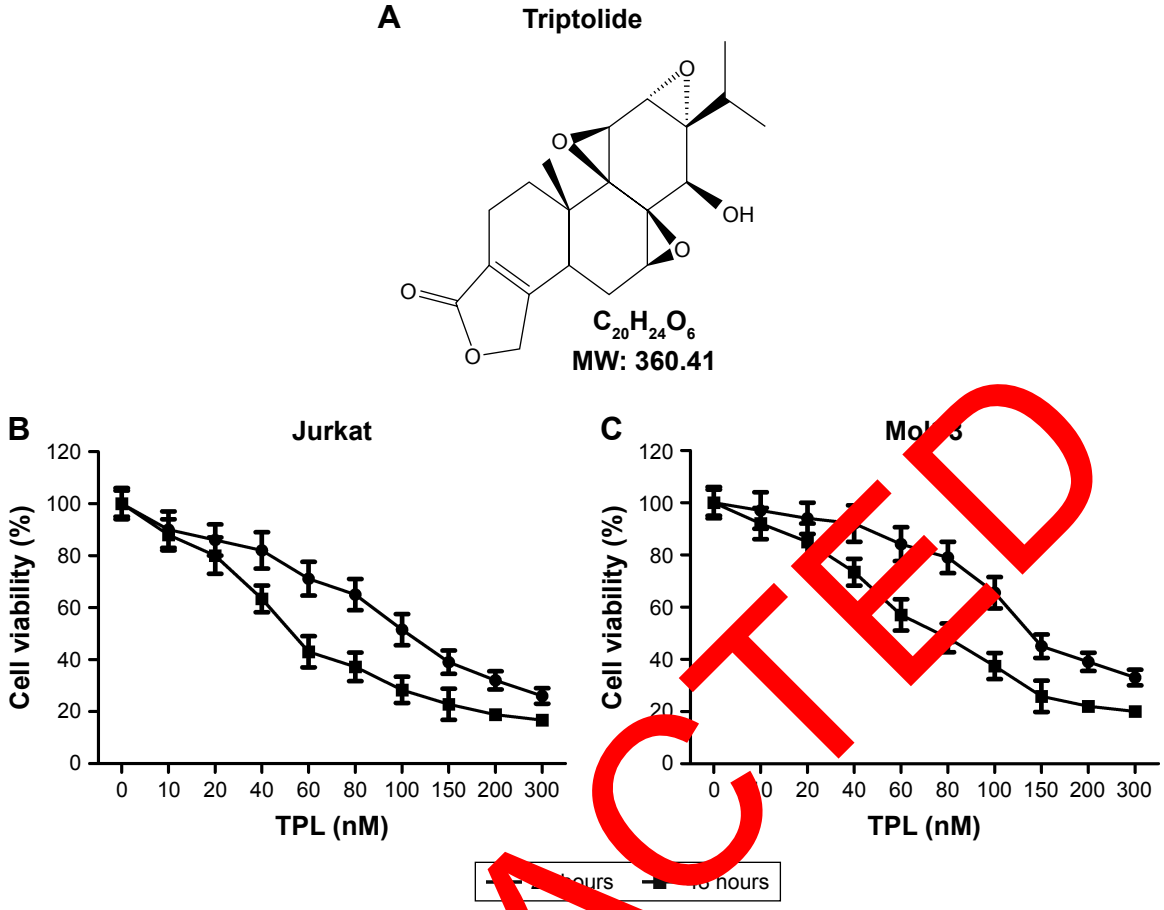

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Figure 1 Antiproliferative effect of TPL on T-LBL cells.
Notes: (**A**) Structure of TPL. (**B** and **C**) Effects of TPL on the proliferation of T-LBL cells (Jurkat cells and Molt-3 cells) were detected by MTT assay respectively.
Abbreviations: T-LBL, T-cell lymphoblastic lymphoma; TPL, triptolide.

at 4°C. The primary antibodies used were as follows (all purchased from Cell Signaling Technology, Danvers, MA, USA): GAPDH, Bax, Bcl-2, matrix metalloproteinase (MMP)-3, MMP-9, E-cadherin, Integrin αVβ6, PI3K, p-AKT, mTOR, P-mTOR, and Snail. After being incubated with the corresponding secondary antibodies (1:2,000; Cell Signaling Technology) for 1 hour at room temperature, the antibody-bound proteins were detected using the ECL system (Bio-Rad Laboratories). Image quantifications were performed using ImageJ software.

Invasion assays

Invasion assays were analyzed using transwell coated with Matrigel. Cells of different groups (1×10^5) were added to the top chamber and allowed to invade through the filter for 24 hours. Then, cells on the top of the filter were removed and cells on the bottom of the filter were fixed in 4% paraformaldehyde. After that, the chambers were stained with crystal violet and analyzed using light microscopy (Olympus, Tokyo, Japan). The assay was completed three times in triplicate with nine random images per filter.

Quantitative real-time polymerase chain reaction

Total RNA was isolated from the cells by TRIzol reagent (Thermo Fisher Scientific) according to manufacturer's instructions. The reverse transcription reaction was performed using the PrimeScript RT reagent Kit (TaKaRa, Shiga, Japan). Quantitative real-time polymerase chain reaction (qRT-PCR) was performed to evaluate the expression of Snail, Slug, and Twist using the QuantiTect SYBR Green RT-PCR Kit on the StepOnePlus™ Real Time PCR System (Thermo Fisher Scientific). Gene expression was standardized to GAPDH expression as an endogenous control, and the relative level was calculated by relative quantification ($2^{-\Delta\Delta Ct}$) method. The primers used were as follows: Snail: F: 5′-CCAATCGGAAGCCTAACTAC-3′, R: 5′-AGAGTCCCAGATGAGCATTG-3′; Slug: F: 5′-CGAA

CTGGACACACATACAG-3′, R: 5′-GAAAGAG GAGAGAGGCCATT-3′; Twist: F: 5′-TCTTACGAG GAGCTGCAGA-3′, R: 5′-AGAGGAAGTCGATGT ACCTG-3′.

Immunofluorescence

Cells in different groups were seeded on slides in the six-well plates. After culturing for 24 hours, cells on slides were fixed in 4% paraformaldehyde in PBS for 5 minutes, and then permeabilized with 0.2% Triton X-100 and 1% bovine serum albumin for 20 minutes at room temperature. After washing in PBS, the cells were incubated with primary anti-AKT monoclonal antibody (Cell Signaling Technology). Then cells were incubated with corresponding secondary antibodies (Pierce, Rockford, IL, USA) for 1 hour at room temperature. The immunoreactivity was revealed using Alexa568-conjugated streptavidin (Molecular Probes, Eugene, OR, USA), and cells were counterstained with 10 mg/mL DAPI. The cells were examined under a fluorescence microscope.

In vivo xenograft model

Four-week-old BALB/C athymic nude mice were purchased from Animal Center of the First Affiliated Hospital of Xinxiang Medical University. Mice were maintained under specific pathogen-free conditions. The animal protocol used in this study was approved by the Medical Ethics Committee of The First Affiliated Hospital of Xinxiang Medical University. All animal experiments complied with the National Institutes of Health Guide for the Care and Use of Laboratory Animals (NIH Publications No. 8023, revised 1978).

Jurkat cells (1×10^7) were injected subcutaneously into the flank area of each animal. Three days postinjection, the mice were randomly divided into control and treatment groups (six mice per group), and daily intraperitoneal injection of different concentrations of TPL (20, 40 and 80 nM) or PBS was performed. The mice were weighed and the tumor volume was measured every 5 days after the formation of tumors. After 25 days postinjection, mice were sacrificed and tumor samples were collected for experiments.

TUNEL assay

Terminal deoxynucleotidyl transferase dUTP nick-end labeling (TUNEL) assay was performed using Colorimetric TUNEL Apoptosis Assay Kit (Beyotime Institute of Biotechnology) according to manufacturer's protocol. Briefly, tumor sections were incubated in 3% H_2O_2 and then in the TUNEL reaction mixture. The sections were rinsed and visualized using diaminobenzidine. Hematoxylin was used for counterstaining. The numbers of TUNEL-positive cells in six random fields were counted under light microscopy. The cell apoptosis rate was calculated as the percent of TUNEL-positive cells relative to the total cells.

Statistical analysis

Experimental data were presented as mean ± standard deviation (SD). The statistical significance of the studies was analyzed using Student's *t*-test. The difference was considered statistically significant at $P<0.05$.

Results

TPL inhibits T-LBL cell viability

Two T-LBL cell lines, Jurkat cells and Molt-3 cells, were exposed to TPL with the concentration ranging from 0 to 300 nM for 24 and 48 hours, and the growth of these two cell lines was found to be inhibited by TPL treatment in a dose-dependent manner (Figure 1B and C). It also showed that Jurkat cells were more sensitive to TPL compared with Molt-3 cells; thus, Jurkat cells were chosen for subsequent experiments. These results indicated that TPL inhibited T-LBL cells viability in a dose-dependent manner.

TPL induces apoptosis of T-LBL cells

Cell apoptosis was analyzed by flow cytometry as described in the section "Flow cytometric analysis". Our results showed that treatment of Jurkat cells with TPL resulted in apoptosis in a dose-dependent manner (**$P<0.01$, ***$P<0.001$, Figure 2A and B). The results of Western blot also showed that the relative expression of apoptosis-related proteins Caspase-3 and Bax was increased and relative expression of Bcl-2 was decreased in a dose-dependent manner in TPL-treated groups compared with those in control group (*$P<0.05$, **$P<0.01$, Figure 2C and D). These results suggested that TPL induced apoptosis of T-LBL cells.

TPL suppresses T-LBL cell invasion

In this study, TPL treatment suppressed the invasion of T-LBL cells compared with that in the control group (*$P<0.05$, **$P<0.01$, Figure 3A and B) in a dose-dependent way. Relative expression of MMP-3 and MMP-9 that degrade extracellular matrix (ECM) to promote invasion was decreased in TPL-treated groups when compared with that in control group in a dose-dependent manner (*$P<0.05$, **$P<0.01$, Figure 3C and D). These results indicated that TPL suppressed T-LBL cell invasion.

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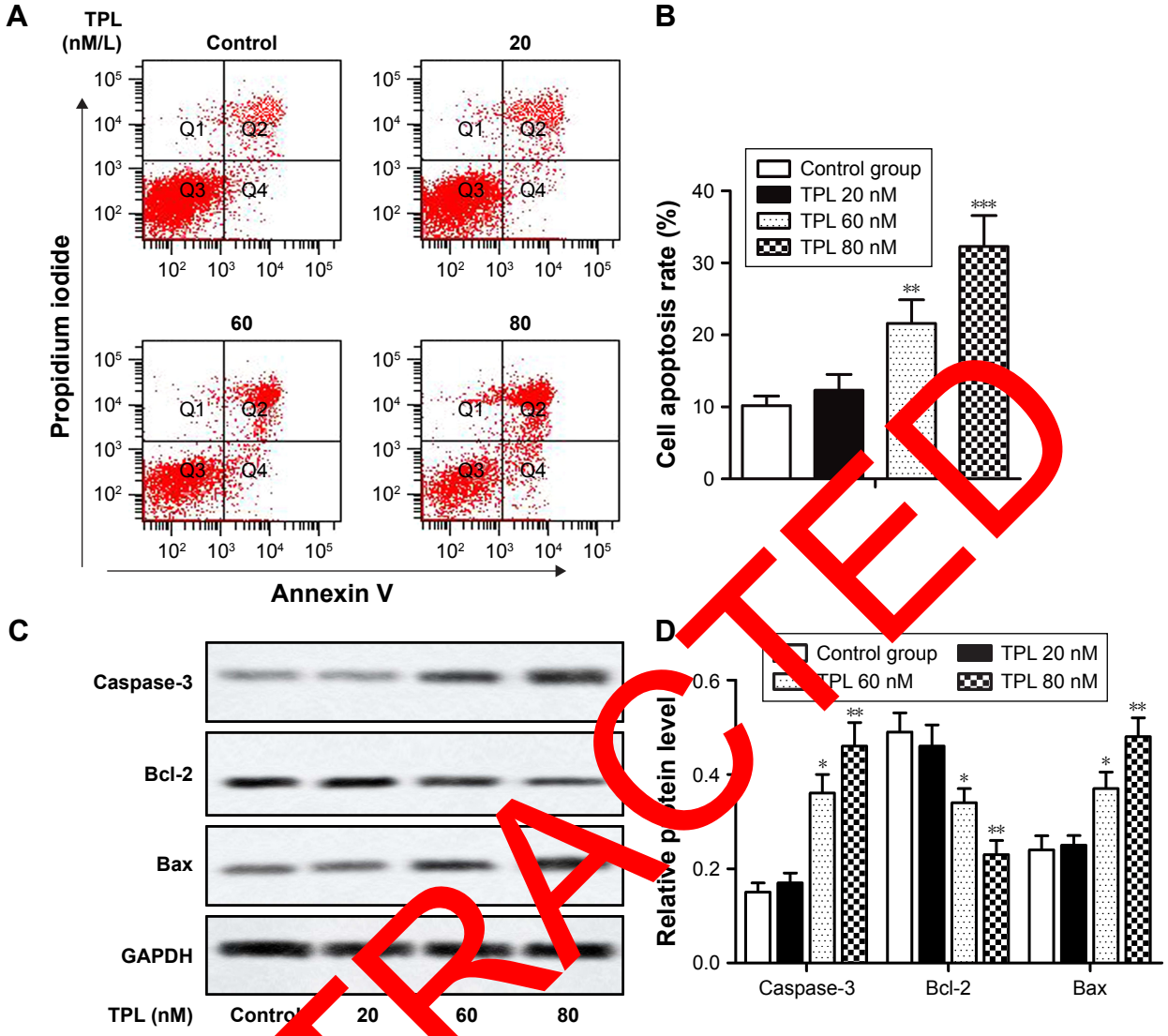

Figure 2 TPL induces apoptosis of T-LBL cells.
Notes: Jurkat cells were treated with different concentrations of TPL (20, 60, and 80 nM). (**A** and **B**) Cell apoptosis rates of control group and TPL-treated groups were analyzed by flow cytometry. (**C** and **D**) Relative protein level of Caspase-3, Bcl-2, and Bax in different groups was measured by Western blot. The bars show mean ± SD of three independent experiments. *$P<0.05$, **$P<0.01$, ***$P<0.001$ compared with control group.
Abbreviations: T-LBL, T cell lymphoblastic lymphoma; TPL, triptolide; SD, standard deviation.

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TPL inhibits EMT of T-LBL cells

The transdifferentiation of epithelial cells into motile mesenchymal cells, a process known as EMT, is reported to promote cancer cell migration and invasion, thus contributing to cancer progression.[15] In this study, relative mRNA level of EMT-related proteins (Snail, Slug, and Twist) was decreased by TPL treatment when compared with that in control group in a dose-dependent way (*$P<0.05$, **$P<0.01$, Figure 4A–C). Moreover, relative protein level of integrin αVβ6, which is reported to be upregulated in various types of cancers, was decreased after TPL treatment. However, relative protein level of epithelial marker E-cadherin was increased by TPL treatment in a dose-dependent manner (*$P<0.05$, **$P<0.01$, Figure 4D). These results suggested that TPL treatment inhibited EMT of T-LBL cells.

TPL inhibits PI3K/AKT/mTOR signaling pathway in T-LBL cells

It was reported that TPL suppressed PI3K/Akt/mTOR signaling pathway in thyroid carcinoma cells.[14] To explore whether TPL treatment could regulate PI3K/Akt/mTOR signaling pathway in T-LBL cells, we examined the effects of TPL treatment on phosphorylation of PI3K, Akt, and mTOR by Western blot. Our data revealed that relative protein level of p-PI3K, p-Akt, and mTOR was significantly decreased by TPL treatment compared with that in control group in a

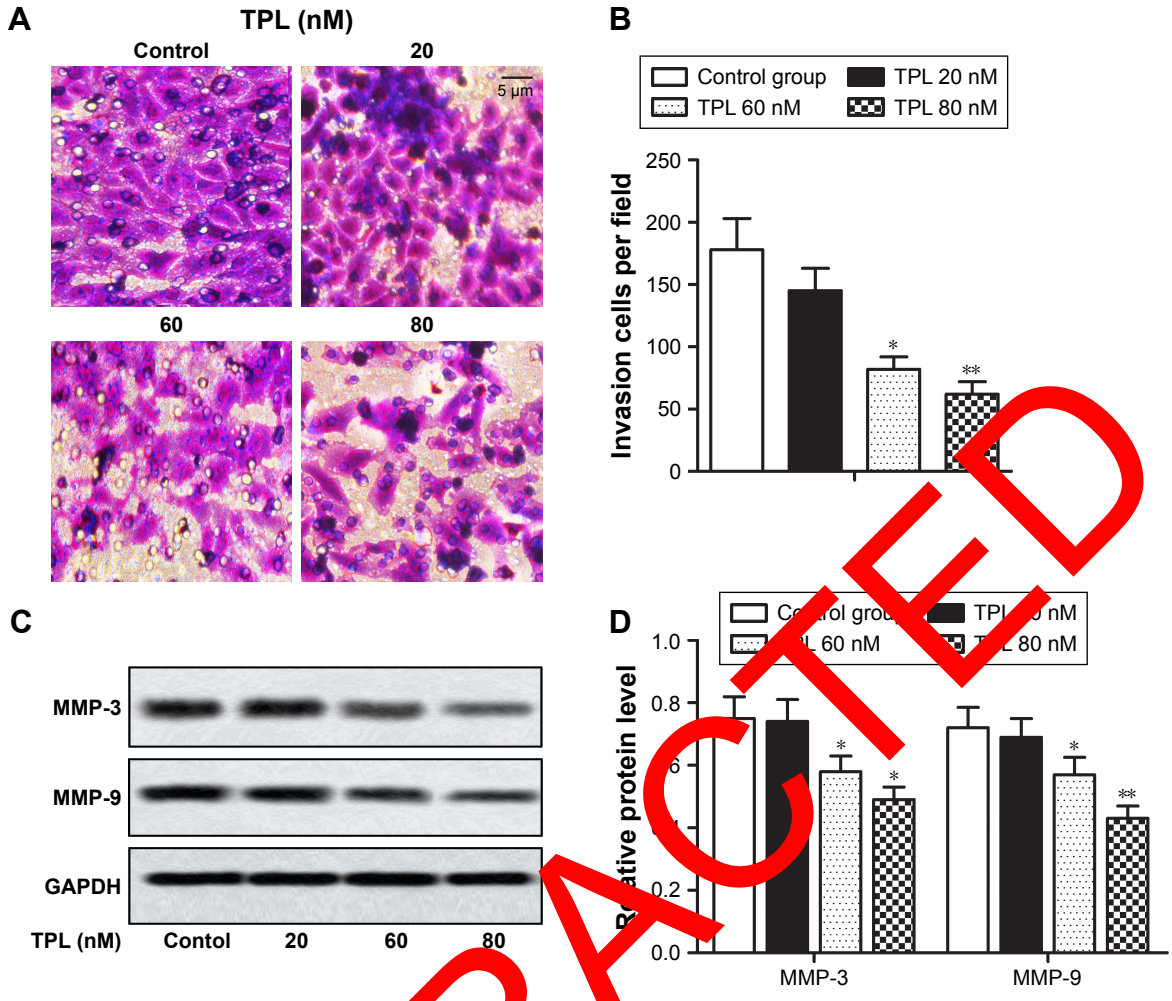

Figure 3 TPL suppresses T-LBL cell invasion.
Notes: Jurkat cells were treated with different concentrations of TPL (0, 20, 60, and 80 nM). (**A** and **B**) Cell invasion ability of different groups was detected using transwell model. (**C** and **D**) Relative protein level of MMP-3 and MMP-9 in different groups was measured by Western blot. The bars show mean ± SD of three independent experiments. *$P<0.05$, **$P<0.01$ compared with control group.
Abbreviations: T-LBL, T-cell lymphoblastic lymphoma; TPL, triptolide; SD, standard deviation.

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dose-dependent manner ($P<0.05$, Figure 5A). Results from immunofluorescence analysis indicated that TPL treatment significantly downregulated AR activation in TPL-treated cells when compared with that in the control group (Figure 5B). Our results indicated that PI3K/Akt/mTOR signaling pathway in T-LBL cells is suppressed by TPL treatment.

The effects of TPL on T-LBL in vivo

To study the effect of TPL on T-LBL progression in BALB/C mice, 1×10^7 of Jurkat cells were injected subcutaneously into flanks of the mice. Our data showed that the rate of body weight loss and the tumor volume were suppressed by TPL treatment compared with those in control group in a dose-dependent manner (*$P<0.05$, **$P<0.01$, Figure 6A and B). Moreover, results from TUNEL assay revealed that cell apoptosis rate was increased by TPL treatment (*$P<0.05$, **$P<0.01$, Figure 6C). Relative protein level of PCNA, Bcl-2, Snail, p-PI3K, p-Akt, and mTOR was decreased by TPL treatment in a dose-dependent manner compared with that in control group (*$P<0.05$, **$P<0.01$, Figure 6D and E). Our data suggested that TPL suppressed tumor growth and promoted tumor cells apoptosis by inhibiting PI3K/Akt/mTOR signaling pathway in Jurkat cell-induced tumors in vivo.

Discussion

The Chinese herb *T. wilfordii* has been used in traditional Chinese medicine for more than 2,000 years. TPL is purified from *T. wilfordii* and has been demonstrated to exert immunosuppressive and anti-inflammatory effects. TPL is effective

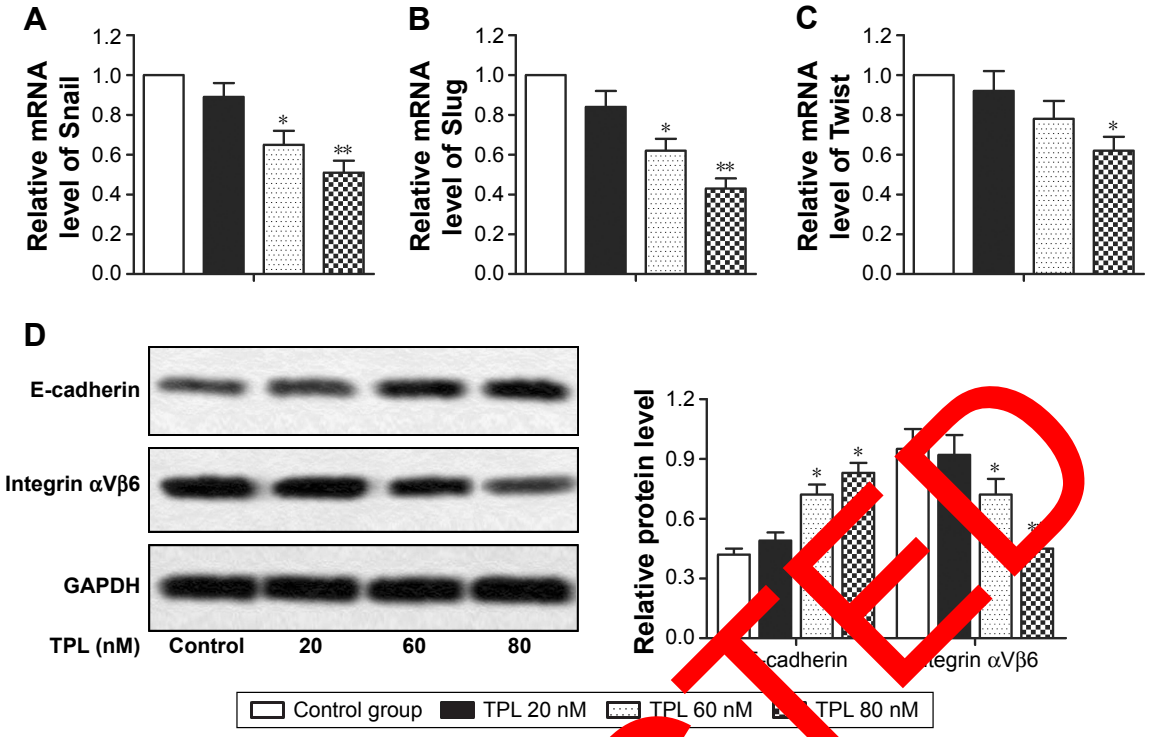

Figure 4 TPL inhibits EPT of T-LBL cells. Jurkat cells were treated with different concentrations of TPL (20, 60, and 80 nM). (**A**–**C**) Relative mRNA level of Snail, Slug, and Twist in different groups was measured by qRT-PCR. (**D**) Relative protein level of E-cadherin and integrin αVβ6 in different groups was measured by Western blot. The bars show mean ± SD of three independent experiments. *$P<0.05$, **$P<0.01$ compared with control group.
Abbreviations: T-LBL, T-cell lymphoblastic lymphoma; EPT, epithelial–mesenchymal transition; TPL, triptolide; qRT-PCR, quantitative real-time polymerase chain reaction; SD, standard deviation.

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for the treatment of a variety of autoimmune diseases [16] also possesses antitumor and male antifertility effects. Nowadays, multiple studies both in vitro and in vivo have shown that TPL exhibited antiproliferation and apoptotic effects in various types of tumors.[17–20] Yinjun Li's[17] research showed that TPL inhibited the proliferation of multiple myeloma cells (RPMI 8226 and U266 cells) in a dose-dependent manner (10–80 ng/mL). TPL also induced apoptosis in multiple myeloma cells by downregulating NF-κB activity. Lou[18] reported that TPL inhibited chronic myelogenous leukemia cell (K562 cells) proliferation and induced apoptosis in a dose- and time-dependent manner. Chan's[19] study also indicated that TPL induced apoptosis in human tumor cell lines (promyelocytic leukemia, T-cell lymphoma, and human hepatocellular carcinoma cell lines). Another study by Chang[20] reported that TPL enhanced apoptosis in fibrosarcoma cell line (HT1080) and NSCLC cell line (A549) by blocking p21-mediated growth arrest. Similarly, in our study, we also found that TPL inhibited the proliferation of T-LBL cell lines, Jurkat cells and Molt-3 cells, in a dose-dependent manner. TPL also enhanced apoptosis in Jurkat cells in our study. TPL inhibited cell viability by suppressing cell proliferation and promoting apoptosis and the related mechanism including activation of Caspase-3 and Bax and downregulation of Bcl-2.

T-LBL is a widely disseminated disease, and CNS involvement is seen in 5%–10% of T-LBL patients.[3] Thus, suppressing metastasis of T-LBL cells can improve 5-year overall survival of patients. Metastasis, which is the major cause of morbidity and mortality of many tumors, is related to the invasion and migration of tumor cells. ECM degradation by extracellular proteinases is a key point for tumor invasion and metastasis.[21] MMP is a family of functionally related zinc containing enzymes that include interstitial collagenases, gelatinases, stromelysin, matrilysin, metalloelastase, and membrane-type MMPs.[22,23] Members from MMP family play important roles in ECM degradation and are related to tumor invasion. As two members of MMP family, MMP-3 and MMP-9 are reported to be upregulated in many human cancers with metastasis capability.[24,25] Apart from that, Yang's[26] study indicated that TPL treatment decreased the activation of MMP-9 and inhibited the migration and invasion of rheumatoid fibroblast-like synoviocytes. Another study from Jao[27] revealed that TPL treatment suppressed

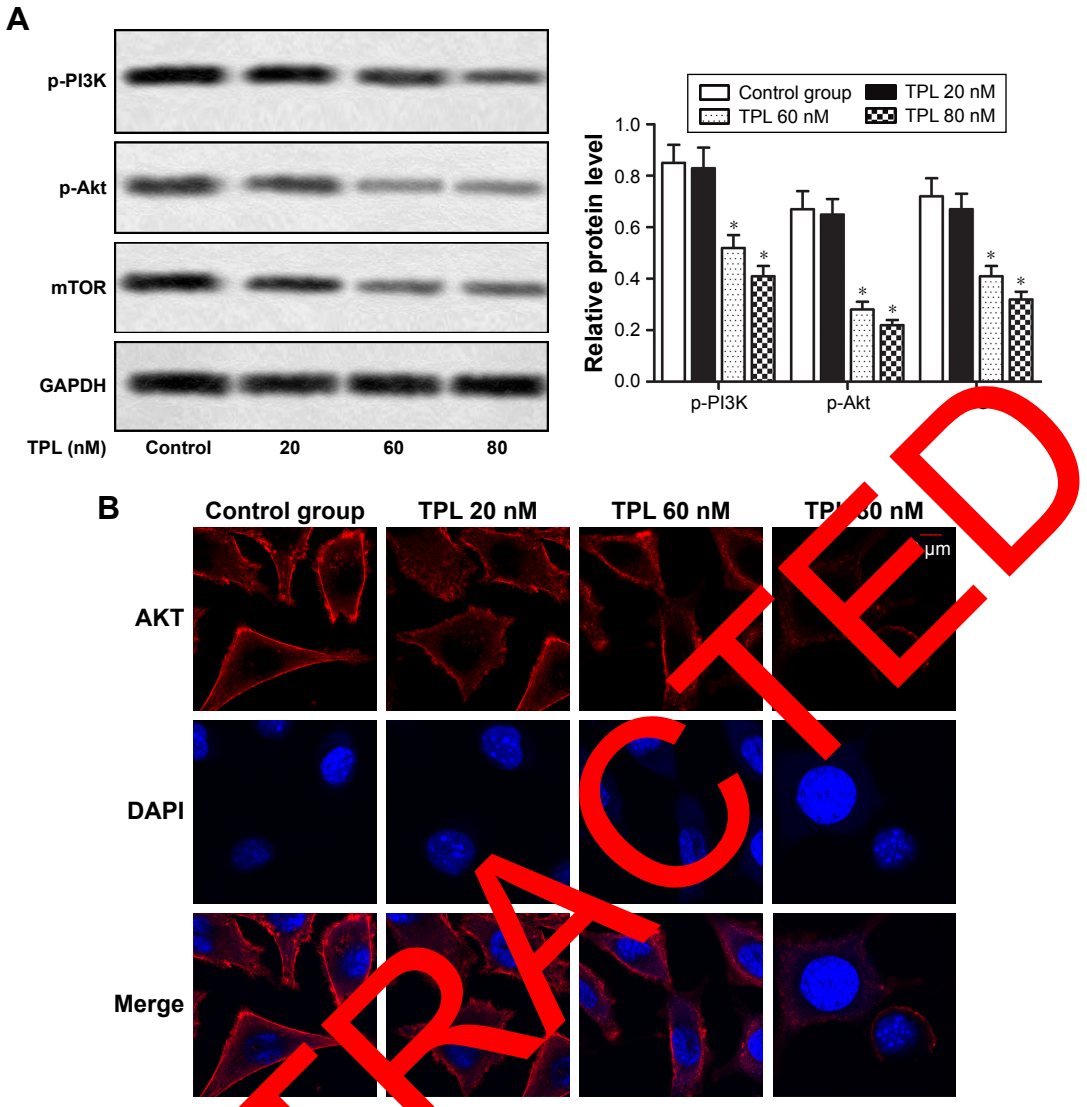

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Figure 5 TPL inhibits PI3K/AKT/mTOR signaling pathway in T-LBL cells.
Notes: Jurkat cells were treated with different concentrations of TPL (20, 60, and 80 nM). (**A**) Relative protein level of p-PI3K, p-Akt, and mTOR in different groups was measured by Western blot. (**B**) The expression of AKT in different groups was detected by immunofluorescence. The bars show mean ± SD of three independent experiments. *$P<0.05$ compared with control group.
Abbreviations: T-LBL, T-cell lymphoblastic lymphoma; TPL, triptolide; SD, standard deviation.

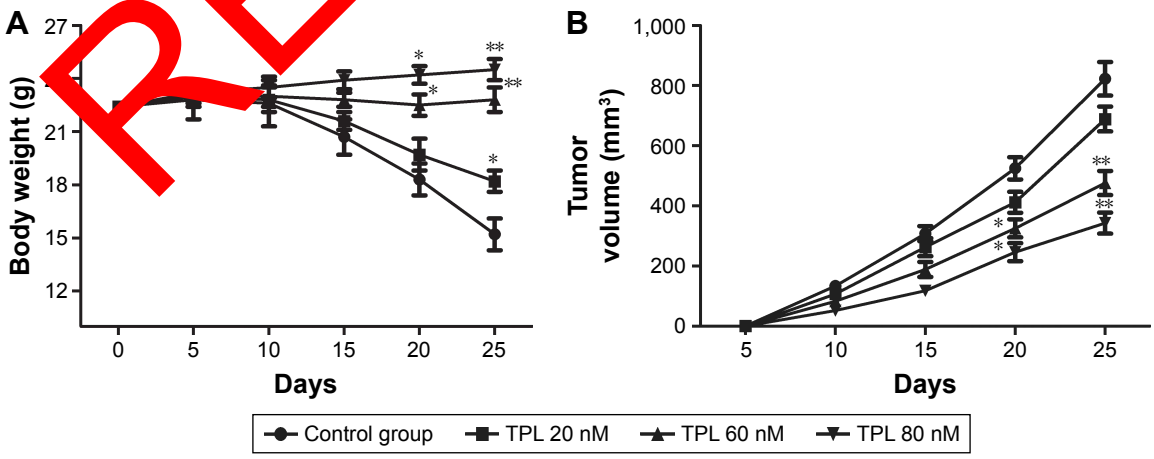

Figure 6 (*Continued*)

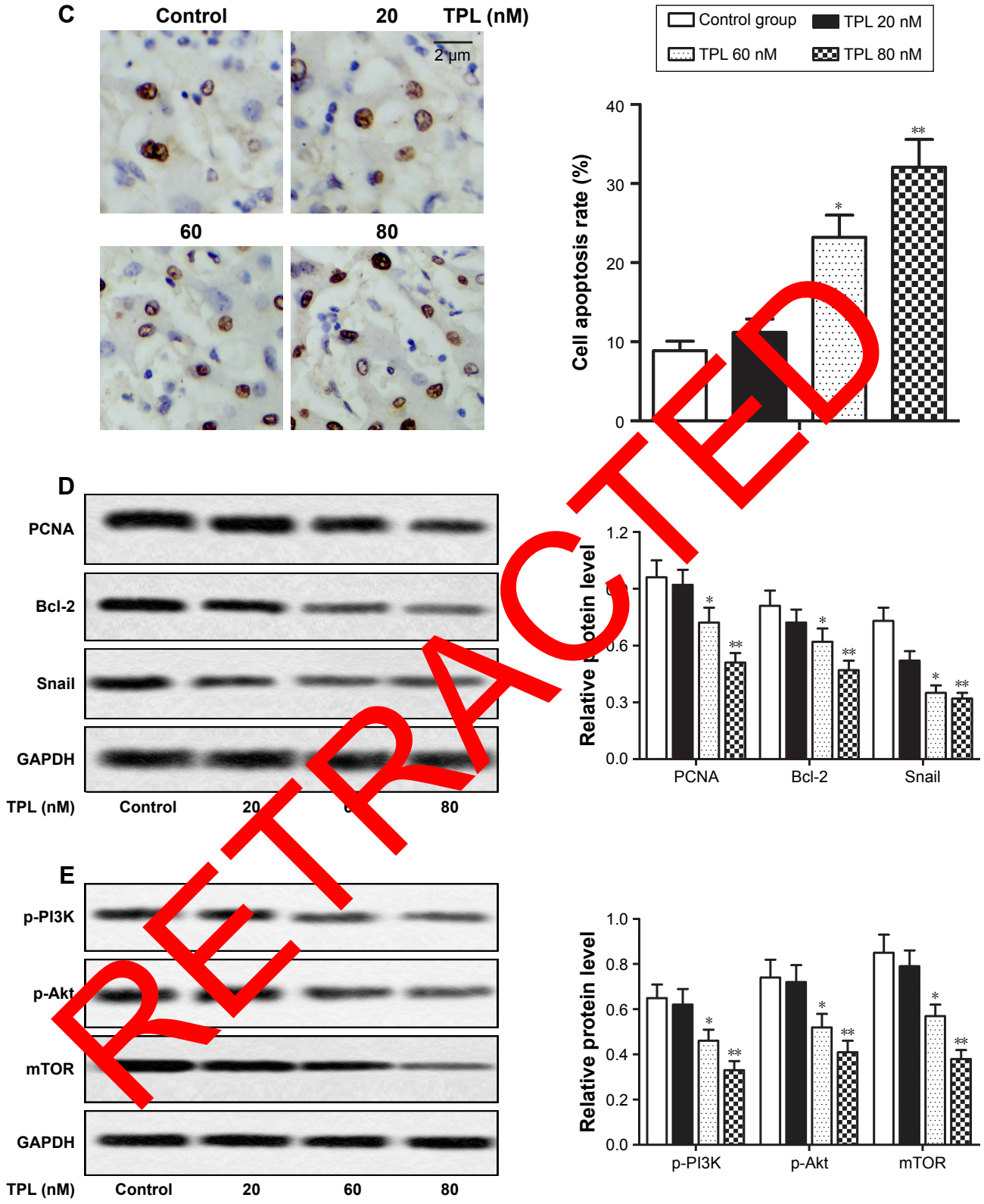

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Figure 6 The effects of TPL on T-LBL in vivo.

Notes: Jurkat cells (1×10^7) were injected subcutaneously into the mice to form tumors. The mice were randomly divided into control and TPL treatment groups (20, 60, and 80 nM). (**A**) The changes in body weight of mice in different groups were measured every 5 days. (**B**) The changes in tumor volume of mice in different groups were measured every 5 days. (**C**) Cell apoptosis rates in different groups were measured by TUNEL assay. (**D**) Relative protein level of PCNA, Bcl-2, and Snail in different groups was measured by Western blot. (**E**) Relative protein level of p-PI3K, p-Akt, and mTOR in different groups was measured by Western blot. The bars show mean ± SD of three independent experiments. *$P<0.05$, **$P<0.01$ compared with control group.

Abbreviations: T-LBL, T-cell lymphoblastic lymphoma; TPL, triptolide; SD, standard deviation; TUNEL, terminal deoxynucleotidyl transferase dUTP nick-end labeling.

migration and invasion of B16F10 mouse melanoma cells by inhibiting the activities of MMP-2 and MMP-9. Consistent with these previous studies, we found that TPL treatment suppressed the invasion ability of T-LBL cells in a dose-dependent manner through the downregulation of MMP-3 and MMP-9. Our results indicated that TPL was a potential antimetastasis agent against T-LBL.

EMT is a cellular switch from epithelial to mesenchymal properties.[28] EMT can reduce intercellular adhesion and promote cell invasion.[29] During EMT, the mesenchymal marker vimentin is upregulated and the epithelial marker E-cadherin, which is transcriptionally repressed by Twist, Snail, and Slug, is downregulated.[30] A previous study showed that activation of the EMT-inducing transcription factor Twist1 was sufficient to promote carcinoma cells to undergo EMT and disseminate into blood circulation.[31] Integrin αVβ6 has been reported to play a critical role in the capability of tumor cells for tissue invasion and metastasis.[32] Moreover, Nomura's[33] study showed that TPL treatment suppressed NF-κB pathway to downregulate EMT and neural invasion in pancreatic cancer. Liu[34] also reported that TPL reverses hypoxia-induced EMT and stemlike features in pancreatic cancer by NF-κB downregulation. In agreement with previous studies, our results showed that TPL treatment upregulated the expression of E-cadherin and downregulated the expression of Snail, Slug, Twist, and integrin αVβ6, indicating that TPL suppressed EMT in T-LBL cells. However, the mechanism of TPL treatment in T-LBL is not fully understood, thus we further investigated the potential involvement of signal pathway in this study.

Previous researches have shown that the activation of PI3K/Akt/mTOR pathway may play an important role in cell proliferation and apoptosis in the brain.[35] As a multifunctional collection point, mTOR, which can be regulated by activated Akt, can regulate cytoskeletophy, energy supply, and signal transduction.[36] Kim's[14] study revealed that TPL combined with BIIB021 exerted synergistic cytotoxicity in thyroid carcinoma cells by suppressing PI3K/Akt/mTOR and NF-κB signal pathways. Similarly, in our study, TPL treatment reduced the expression of p-PI3K, p-Akt, and mTOR in a dose-dependent manner in T-LBL cells, suggesting that the activity of PI3K/Akt/mTOR signal pathway was suppressed in T-LBL cells by TPL treatment.

Having understood the mechanism of TPL treatment on T-LBL in vitro, we further carried out in vivo experiments. Research by Zhou[37] also revealed that TPL showed a significant effect on inhibition of the tumor growth caused by B95-8 cells on BALB/c nude mice. In accordance with aforementioned research, our data showed that TPL treatment inhibited tumor growth caused by Jurkat cells on BALB/C nude mice in a dose-dependent manner. TPL also promoted apoptosis of T-LBL cells by suppressing PI3K/Akt/mTOR signal pathway.

Taken together, this study demonstrated that TPL induced cell apoptosis and inhibited metastasis and EMT to suppress T-LBL progression via suppressing PI3K/Akt/mTOR signal pathway. Both these in vitro and in vivo results indicate that TPL possesses antitumor potential against T-LBL.

Author contributions

All authors contributed toward data analysis, drafting and revising the paper and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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