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Original Article

Astragalus polysaccharides inhibits nasopharyngeal carcinoma progression through the mediation of the Akt/mTOR pathway and the induction of oxidative stress

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Abstract: To investigate whether astragalus polysaccharides (APS) can inhibit the progression of nasopharyngeal carcinoma (NPC) and its underlying mechanisms, we conducted both cell and animal experiments. In NPC tissues and cell lines, the level of SNHG12 was significantly elevated, and high levels of SNHG12 were associated with advanced TNM staging, as well as increased cell viability and invasiveness. We further explored the mechanism by which SNHG12 promotes NPC progression and found multiple binding sites between SNHG12 and miR-30a-3p (miR-30a). The expression of miR-30a was significantly decreased in NPC tissues and cell lines, showing a strong negative correlation with SNHG12 levels. Moreover, SNHG12 could counteract the anti-cancer effects of miR-30a, enhancing the viability and migratory ability of CNE-2 cells. Further studies revealed that miR-30a could target and inhibit AKT3 levels, while SNHG12 could antagonize miR-30a and restore AKT3 levels. Thus, SNHG12 can regulate the malignant biological characteristics of NPC by targeting the miR-30a/AKT3 axis. In animal experiments, we found that APS can downregulate SNHG12 and upregulate miR-30a in tumor tissues, effectively suppressing NPC progression. Additionally, APS demonstrated significant antioxidant effects. Therefore, APS can inhibit oxidative stress and suppress NPC progression by targeting the SNHG12/miR-30a/AKT3 signaling pathway.

Keywords: Astragalus polysaccharides, nasopharyngeal carcinoma, SNHG12, miR-30a-3p, oxidative stress

Introduction

Nasopharyngeal carcinoma (NPC) is a malignant tumor originating in the nasopharynx, characterized by high incidence and mortality rates. Recent epidemiological data show that the annual incidence of NPC in China exceeds 20 cases per 100,000 people, with an even higher rate in Guangdong Province, reaching approximately 30 cases per 100,000 [1]. The main risk factors for NPC include genetic susceptibility, environmental factors, and Epstein-Barr virus (EBV) infection, particularly the abnormal expression of key genes that promote the malignant biological characteristics of NPC [2]. Despite advancements in radiotherapy and chemotherapy, patient survival outcomes remain suboptimal due to the tumor's high heterogeneity and drug resistance. As a result, molecular genetics has gradually become a crucial area of NPC treatment studies [3, 4]. LncRNAs and miRNAs, as emerging regulatory factors, have been recognized for their significant roles in tumor occurrence and progression. Therefore, studying the roles of lncRNAs and miRNAs in NPC could provide valuable insights into its mechanisms research and facilitate the exploration of novel targeted and personalized treatment strategies.

In tumor molecular biology, lncRNAs have emerged as a key research hotspot. Recent studies have shown that lncRNAs play crucial roles in regulating gene expression, cell proliferation, differentiation, and apoptosis [5, 6]. lncRNA-SNHG12, as a newly discovered lncRNA, has been shown to promote tumor progression in various cancers [7, 8]. Research

indicates that elevated levels of SNHG12 are closely associated with tumor invasiveness and poor prognosis, with its mechanism of action primarily involving interaction with miRNAs to regulate the expression of downstream target genes, thereby influencing tumor cell behavior.

miR-30a-3p (miR-30a) is a tumor-suppressing miRNA that has been shown to inhibit cell proliferation and migration in various cancers [9, 10]. Research indicates that miR-30a targets the Akt signaling pathway, inhibiting the activation of key regulatory factors such as mechanistic target of rapamycin (mTOR), thereby interfering with cell proliferation and survival [11]. The AKT/mTOR signaling pathway, as a critical intracellular signaling cascade, plays a pivotal role in the occurrence and progression of NPC. Aberrant activation of this pathway can promote NPC development. Furthermore, clinical research has revealed that elevated expression of molecules associated with this pathway are closely correlated with poor prognosis in NPC patients. Currently, there are few studies on the interaction between SNHG12 and miR-30a. Understanding the SNHG12/miR-30a axis may provide new insights into the pathogenesis of NPC, offering potential therapeutic targets.

Astragalus polysaccharides (APS), a bioactive component extracted from *Astragalus*, have been widely studied in recent years [12]. Astragalus is a traditional Chinese medicine known for its various biological activities, including immune enhancement, antioxidant effects, and anti-tumor properties [13]. Research indicates that APS can inhibit tumor cell growth through multiple mechanisms, such as inducing apoptosis, suppressing tumor cell migration, and modulating the tumor microenvironment [14]. Particularly, its role in regulating oxidative stress and signaling pathways highlights its potential application value in cancer therapy. Studies have shown that APS can significantly induce autophagy and apoptosis in NPC cells by inhibiting the AKT/mTOR pathway, thereby suppressing tumor growth and enhancing sensitivity to radiotherapy or chemotherapy. However, the precise molecular mechanisms through which APS exerts its antitumor effects via the AKT/mTOR pathway remain insufficiently explored.

This study aims to investigate the inhibitory effects of APS on NPC cells, with a focus on analyzing the interaction between the SNHG12/miR-30a axis and the Akt-mTOR pathway. Through both cell and animal experiments, we systematically explore how APS regulates the expression of lncRNAs and miRNAs, influencing the biological characteristics of tumor cells and tumor growth. This research seeks to provide novel insights and strategies for the prevention and treatment of NPC.

Materials and methods

Materials and animals

The normal nasopharyngeal epithelial cell line NP69 and NPC cell lines SUNE1, 5-8F, CNE-1, and CNE-2 were kindly provided by Sun Yat-sen University and Xiang-Ya School of Medicine. APS (batch number SC10661032460141) were purchased from Shaanxi Ciyuan Biotechnology Co., Ltd. Assay kits for superoxide dismutase (SOD, CS0009), glutathione peroxidase (GSH-Px, CGP1), and catalase (CAT, MAK381) were obtained from Sigma-Aldrich, St. Louis, MO, USA. RPMI 1640 medium (11879020), keratinocyte-SFM medium (170-05042), RNA Extraction Kit (PureLink, 121-83020), and Reverse transcription kit (SuperScript, 18090010) were purchased from Thermo Fisher Scientific, Waltham, MA, USA. Anti-AKT3 antibody (ab152157), anti-mTOR antibody (ab134903), Alexa Fluor® 647 (ab150079), Alexa Fluor® 568 (ab175471), anti-Ki67 (ab15580), Fluorescein Isothiocyanate (FITC, ab6717) and 4',6-Diamidino-2-Phenylindole (DAPI, ab285390) were acquired from Abcam, USA. Additionally, 24 male SD rats weighing approximately 300 g were selected for establishing NPC models. The animals were individually housed in the animal center under controlled conditions (24°C, 30 to 60% humidity) with free access to standard diet and drinking water. Animal experiments were approved by the ethics committee of Shunde Hospital of Southern Medical University.

Sample collection

A retrospective analysis was conducted on the clinical data of NPC patients treated at Shunde Hospital of Southern Medical University from February 2017 to February 2022. Inclusion criteria: 1. Pathologic diagnosis of NPC; 2. Undergoing biopsy or surgical treatment of the nasopharynx; 3. Complete medical

Table 1. Primers for PCR assay

	F primer	R primer
miR-30a-3p	5'-CGGGCTTGTGGAATGGTAAGC-3'	5'-GGGCATACATCGGCTAATACA-3'
U6	5'-GCTTCGGCAGCACATATACTAAAAT-3'	5'-CGCTTCACGAATTTGCGTGTCAT-3'
SNHG12	5'-TCTGGTGATCGAGGACTTCC-3'	5'-ACCTCCTCAGTATCACACACT-3'
AKT3	CTCCATGCTTCTATCCTTCC	GTAGTTAGCTCTGCTCTTCC
GAPDH	5'-GGTGAAGGTCGGTGTGAACG-3'	5'-GCTCCTGGAAGATGGTGATGG-3'

history, including clinical case records and pathological specimens. Exclusion criteria included: 1. Presence of other malignancies; 2. Receipt of radiotherapy or chemotherapy prior to biopsy or surgery; 3. Treatment with targeted or immunosuppressive drugs within four weeks before hospitalization. A total of 78 patients were included in the study. Our research was approved by the ethics committee of Shunde Hospital of Southern Medical University.

Cell culture

NPC cells were cultured in RPMI 1640 supplemented with 10% FBS, penicillin (100 U/mL), and streptomycin (100 μg/mL). NP69 cells were maintained in keratinocyte-SFM. Cells were incubated at 37°C with 5% CO_2 for 24 h, after which they were diluted to 1 × 10^6 cells/L.

CNE-2 cell transfection

The target gene of SNHG12 was predicted using bioinformatics methods and identified miR-30a as a potential target. Small interfering RNAs targeting SNHG12, pcDNA SNHG12, and miR-30a mimics were obtained from GenePharma (Shanghai, China) for overexpression and silencing studies. Transfections were conducted using Lipofectamine 2000. After 6 hours of transfection, CNE-2 cells were classified into the following groups: control group (no intervention), SNHG12(+)/SNHG12(-) group, miR-30a(+) group, and SNHG12(+)miR-30a(+) group. The cells were subsequently cultured for an additional 24 hours and diluted to a concentration of 1 × 10^6/L.

CNE-2 cell activity

The morphology of CNE-2 cells in each group was observed using a differential interference contrast (DIC) microscope (BX53, OLYMPUS, JAPAN). Subsequently, Anti-Ki67 was added to label the surviving cells, followed by incubation with FITC-conjugated secondary antibody. DAPI (ab285390) was used to stain the nuclei of the cells. Finally, the fluorescence of the surviving cells in each group was assessed using confocal microscopy (SP8, Leica, Wetzlar, Germany).

CNE-2 cell migration

A scratch was created on the cell layer using a pipette, and any detached CNE-2 cells were washed off with PBS solution. After incubating the cells in serum-free medium for 24 hours, the distance of cell migration in each group was observed.

Detection of SNHG12/miR-30a/AKT3

Levels of SNHG12, miR-30a, and AKT3 in each group were measured using PCR (**Table 1**). Total RNA was isolated from NPC in each group using an RNA extraction kit and reverse transcribed using a reverse transcription kit. RT-PCR was then performed to detect miR-30a and SNHG12/AKT3 levels in each group, using U6 or GAPDH as an internal reference.

Immunofluorescence

CNE-2 cells in each group were treated with anti-AKT3 antibody to label AKT3, followed by the addition of Alexa Fluor® 647 as the secondary antibody. Similarly, mTOR was labeled using anti-mTOR antibody, with Alexa Fluor® 568 as the secondary antibody. The fluorescent staining of the cells in each group was then observed using a confocal microscope.

Establishment of NPC rat models

After anesthetizing the rats with an intraperitoneal injection of 3% pentobarbital sodium (0.2 ml/100 g), 100 μL of CNE-2 cell dilutions (1 × 10^6/L) prepared as described in section 2.4 was injected subcutaneously into rats' back [15]. The rats were randomly divided into the following groups: control, miR-305(+),

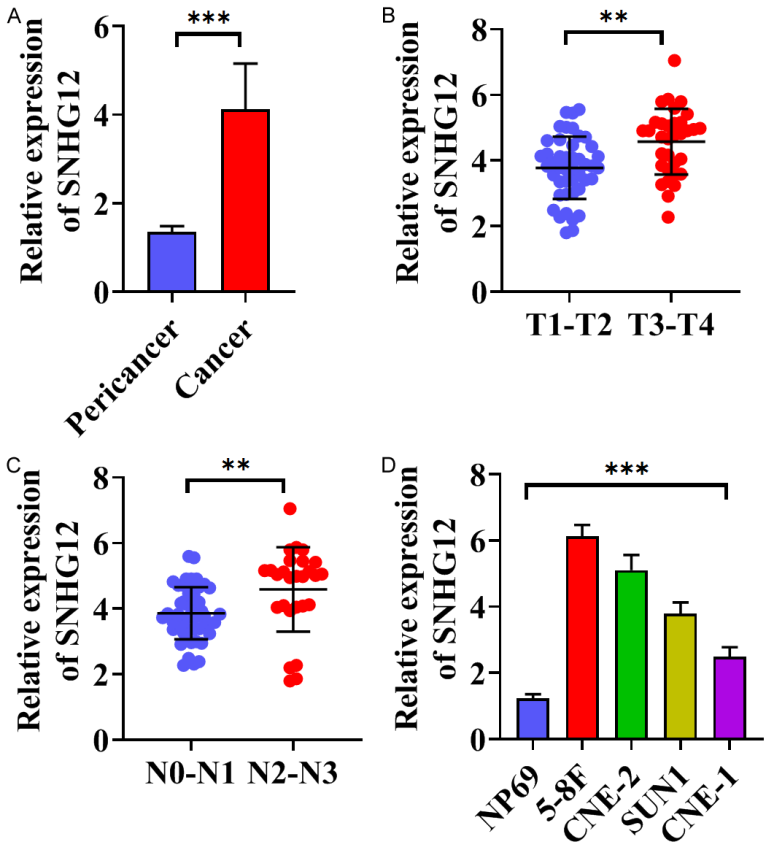

Figure 1. Detection of SNHG12 levels. A: SNHG12 levels in NPC tissue. B: SNHG12 levels in patients with different T stages. C: SNHG12 levels in patients with different N stages. D: SNHG12 levels in different NPC cells. NPC: nasopharyngeal carcinoma. $^{**}P < 0.01$, $^{***}P < 0.001$. Patient, n = 78; Cell, n = 3.

SNHG12(+), and SNHG12(+)miR-305(+) groups, with 9 rats in each group. On the second day after modeling, three rats from each group were randomly selected and treated with APS solution (1 mg/mL, 50 mg/kg) to form the APS groups (four groups of 12 rats). The solution was diluted with 0.9% sodium chloride and administered once daily for 14 consecutive days. The remaining groups were treated with saline and established as the blank groups (four groups of 12 rats).

Antitumor effects of APS

The tumor volume of the rats was measured using a vernier caliper every three days. On day 21, the rats were sacrificed by carbon dioxide asphyxiation, and tumor tissue from the back was collected for weight measurement. Additionally, the levels of SNHG12 and miR-30a in the rat tumor tissues from the Blank and APS groups were assessed using PCR.

Antioxidant effects of APS

On day 21, blood samples from each group of rats were collected and centrifuged. The serum levels of SOD, GSH-Px, and CAT were then measured using the kits.

Statistical analysis

SPSS 22.0 and GraphPad Prism7 were adopted for statistical analysis. The qualitative data was described by x ± s. The two-tailed student's t-test was applied to assess significant differences between two groups, and one-way analysis of variance (ANOVA) with Tukey's tests was to determine the differences among multiple groups. Person correlation analysis was used to detect the correlation between miR-30a and SNHG12. A *p*-value of < 0.05 was considered statistically significant.

Results

Significant upregulation of SNHG12 in NPC

PCR analysis of SNHG12 levels in tumor tissues from NPC patients revealed a significant upregulation of SNHG12 in NPC tissues compared to adjacent non-cancerous tissues (**Figure 1A**). Furthermore, patients with T3-T4 and N2-N3 stages exhibited significantly higher levels of SNHG12 than those with T1-T2 and N0-N1 stages (**Figure 1B**, **1C**). Additionally, SNHG12 level in NPC cell lines was notably higher than that in NP69 cells (**Figure 1D**).

SNHG12 significantly enhanced CNE-2 cell viability and invasiveness

Under DIC microscopy, a higher density of CNE-2 cells was observed in the SNHG12(+) group (**Figure 2A-C**). Additionally, the number of Ki-67(+) CNE-2 cells was markedly increased in the SNHG12(+) group, indicating that high

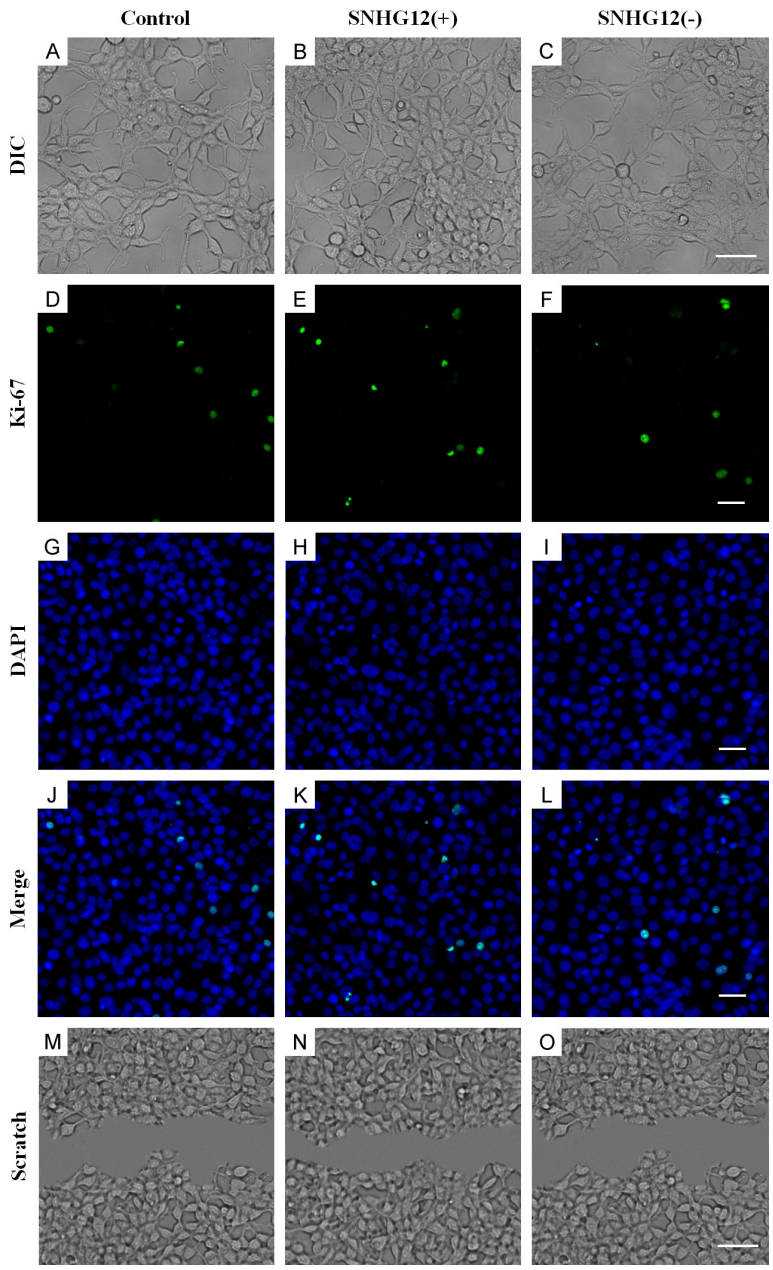

Figure 2. Detection of CNE-2 cell viability and invasiveness. A-C: The growth of CNE-2 cells cultured alone or with over or silent expression of SNHG12, 40×. D-L: anti-Ki-67 expression in CNE-2 cells cultured alone or with over or silent expression of SNHG12, 40×. M-O: Scratch test of CNE-2 cells cultured alone or with over or silent expression of SNHG12, 40×. DIC: differential interference contrast, DAPI: 4',6-Diamidino-2-Phenylindole. Scale bar: 20 μm. N = 3

expression of SNHG12 markedly enhanced CNE-2 cell proliferation (**Figure 2D-L**). In invasion assays, the migratory ability of CNE-2 cells in the SNHG12(+) group was markedly enhanced, suggesting that SNHG12 effectively increased the invasive capacity of CNE-2 cells (**Figure 2M-O**).

miR-30a as a Target of SNHG12

Bioinformatics screening identified binding sites between SNHG12 and miR-30a, indicating a potential interaction within the SNHG12/miR-30a axis in NPC development (**Figure 3A**). In NPC tissues and cell lines, miR-30a levels were markedly decreased, showing a strong negative correlation with SNHG12 levels (**Figure 3B-D**). Transfection experiments revealed that both SNHG12 and miR-30a levels were significantly elevated in CNE-2 cells (**Figure 3E**); however, high SNHG12 expression notably inhibited miR-30a levels in these cells (**Figure 3F**). Thus, SNHG12 can directly target and suppress miR-30a expression in NPC cells.

SNHG12 promoted NPC progression by targeting miR-30a

Compared to the control and SNHG12(+)/miR-30a(+) groups, the cell density in SNHG12(+) group showed a great increase under DIC microscopy, while the cell density in miR-30a(+) group decreased markedly (**Figure 4A-D**). Confocal microscopy revealed no significant difference in the number of Ki-67(+) CNE-2 cells between the control and SNHG12(+)/miR-30a(+) groups, but the number increased markedly in the SNHG12(+) group, in contrast to a great decrease in the miR-30a(+) group (**Figure 4E-P**). In invasion assays, the migratory ability of CNE-2 cells in the SNHG12(+)

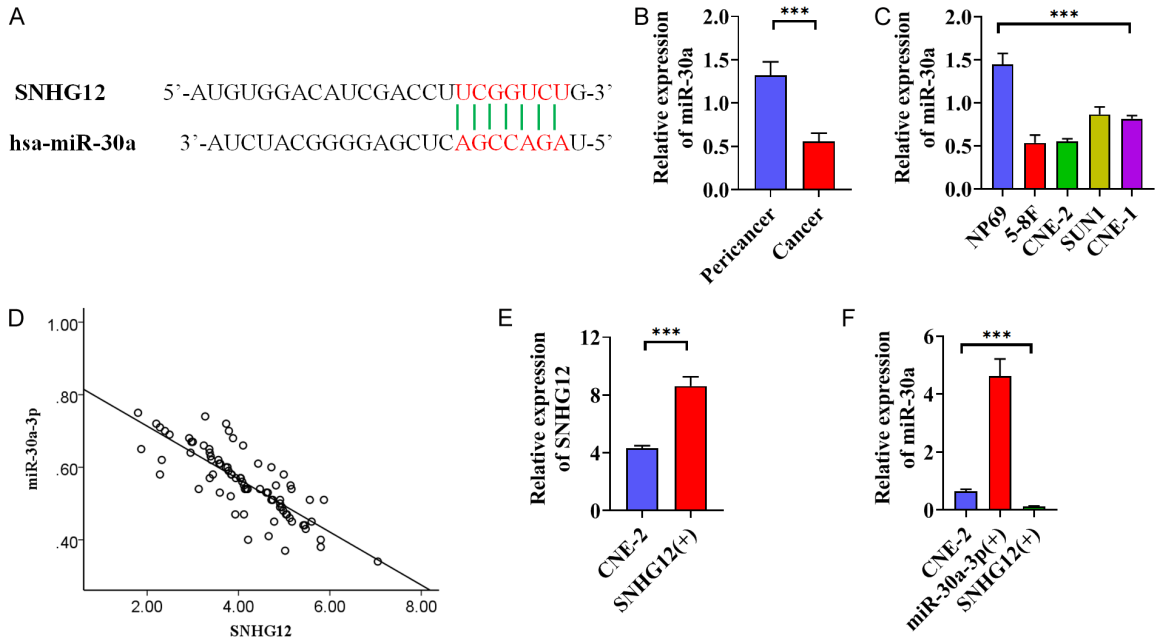

Figure 3. Detection of miR-30a levels. A: The binding sites between SNHG12 and miR-30a. B: miR-30a levels in NPC tissue. C: miR-30a levels in NPC cell lines. D: Correlation analysis between SNHG12 and miR-30a. E: SNHG12 levels in CNE-2 cells cultured alone or with over expression of SNHG12. F: miR-30a levels in CNE-2 cells cultured alone or with over expression of miR-30a, SNHG12. miR-30a: miR-30a-3p. ***$P < 0.001$. Patient, n = 78; Cell, n = 3.

group was markedly enhanced, in contrast to a great decrease in the miR-30a(+) group (**Figure 4Q-T**). These results suggest that SNHG12 antagonizes miR-30a, promoting the viability and migratory capacity of CNE-2 cells.

miR-30a targeted and regulated the AKT3/mTOR signaling pathway

Bioinformatics analysis revealed that miR-30a had binding sites for AKT3, suggesting that the SNHG12/miR-30a axis may regulate NPC expression by modulating the AKT3/mTOR signaling pathway (**Figure 5A**). Compared to NP69 cells, AKT3 levels were markedly elevated in CNE-2 cells (**Figure 5B**). Transfection experiments demonstrated that the high expression of miR-30a obviously inhibited AKT3 levels in CNE-2 cells, whereas high expression of SNHG12 effectively increased AKT3 levels and restored AKT3 levels that were reduced by miR-30a overexpression (**Figure 5C-F**). Additionally, compared to the control and SNHG12(+)/miR-30a(+) groups, AKT3 and mTOR levels were markedly elevated in the SNHG12(+) group, in contrast to a great decrease in the miR-30a(+) group (**Figure 5G-J**). Therefore, the SNHG12/miR-30a axis can target and regulate the AKT3/mTOR signaling pathway.

SNHG12 targeted and regulated miR-30a to promote NPC progression in rat models

Measurement of the levels of SNHG12 and miR-30a in tumor tissues across groups, revealed that SNHG12 levels were markedly elevated in both the SNHG12(+) and SNHG12(+)/miR-30a(+) groups (**Figure 6A**). Similarly, miR-30a levels were markedly increased in the SNHG12(+)/miR-30a(+) and miR-30a(+) groups (**Figure 6B**). These results indicate that NPC rat models with varying levels of SNHG12 and miR-30a were successfully established through transfection experiments. No significant differences were observed in tumor weight or volume between the control and SNHG12(+)/miR-30a(+) groups; however, tumor tissue proliferation was notably inhibited in the miR-30a(+) group, while SNHG12(+) greatly enhanced the proliferation rate (**Figure 6C-E**). Therefore, SNHG12 promotes NPC progression by targeting and inhibiting miR-30a.

APS inhibited NPC progression in rat models by mediating the SNHG12/miR-30a Axis

APS treatment markedly decreased SNHG12 levels across all groups, while simultaneously increasing miR-30a levels (**Figure 7A**, **7B**). Addi-

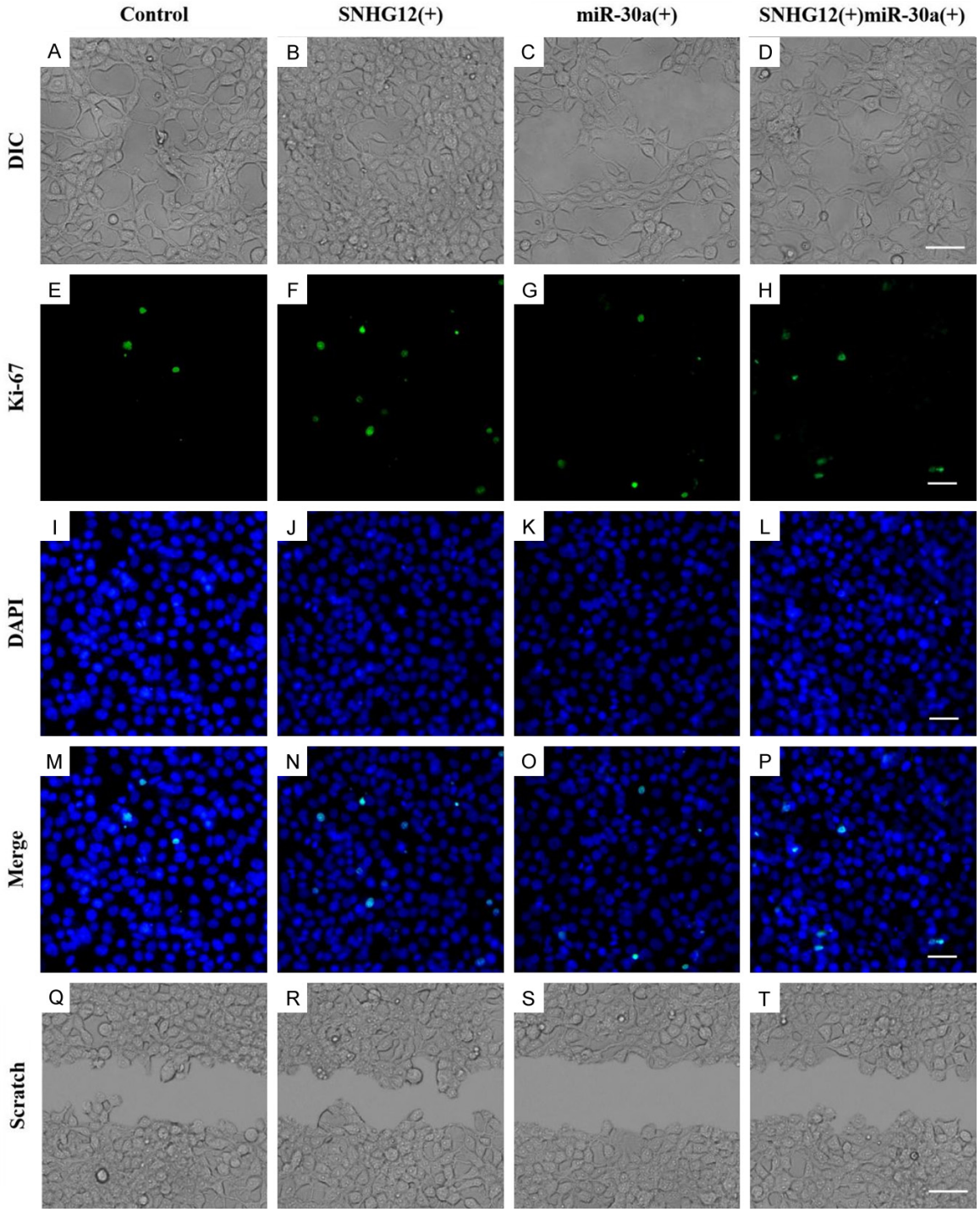

Figure 4. Detection of CNE-2 cell viability and invasiveness. A-D: The growth of CNE-2 cells in different groups, 40×. E-P: anti-Ki-67 expression in CNE-2 cells in different groups, 40×. Q-T: Scratch test of CNE-2 cells in different groups, 40×. DIC: differential interference contrast, miR-30a: miR-30a-3p, DAPI: 4',6-Diamidino-2-Phenylindole. Scale bar: 20 μm. n = 3.

tionally, APS markedly reduced tumor weight and volume in all groups (**Figure 7C-E**). These findings indicate that APS inhibits NPC proliferation by modulating the SNHG12/miR-30a axis.

APS effectively inhibited oxidative stress in NPC rat models

To evaluate the effect of APS on oxidative stress, we measured the levels of SOD, GSH-

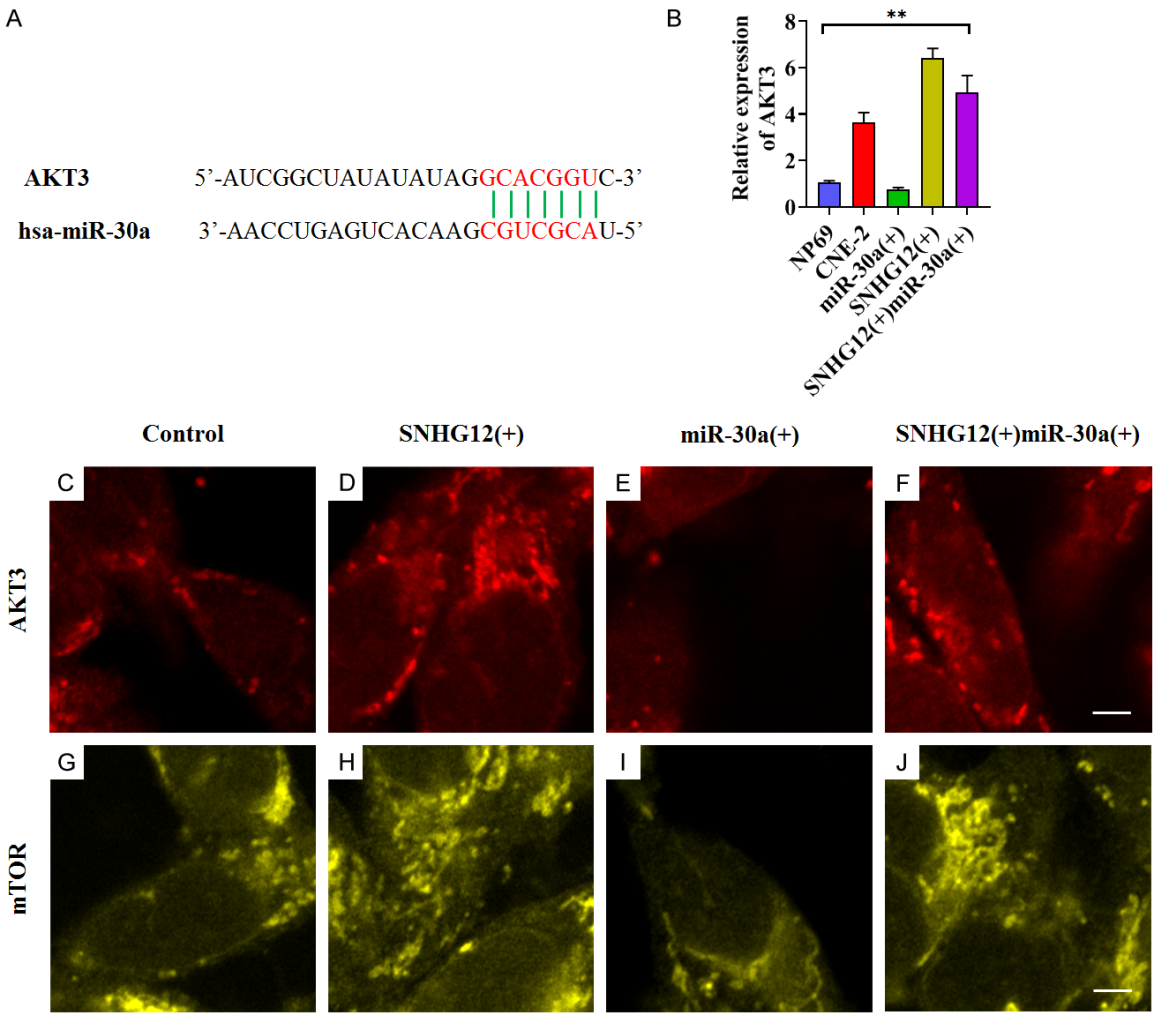

Figure 5. Detection of AKT3/mTOR signaling pathway. A: The binding sites between miR-30a and AKT3. B: AKT3 levels in NPC cell lines. C-F: AKT3 expression in different groups, 40×. G-J: mTOR expression in different groups, 40×. mTOR, mechanistic target of rapamycin, NPC: nasopharyngeal carcinoma, miR-30a: miR-30a-3p. Scale bar: 20 μm. n = 3.

Px, and CAT in the tumor tissues. APS significantly increased the levels of SOD, GSH-Px, and CAT in NPC rat models (**Figure 8**), indicating that APS is effective in suppressing oxidative stress in NPC rats.

Discussion

Currently, radiation therapy remains the primary treatment for controlling the aggressive growth of NPC due to a lack of specific therapeutic targets [16]. However, the unique anatomical features of the nasopharynx and the high doses required for effective radiation often result in significant adverse reactions in patients, such as oral ulcers, difficulty swallowing, loss of taste and smell, skin swelling, pain, peeling, and systemic fatigue [17, 18]. These side effects severely impact patients' quality of life and mental health. While advances in radiation technology have improved treatment outcomes for NPC, there is still a lack of specific hinders the development of more personalized treatment. Therefore, it is essential to understand the underlying mechanisms of NPC pathogenesis to identify potential therapeutic targets and develop more precise and effective treatment strategies.

Currently, SNHG12 has been found to be markedly upregulated in various tumors, such as hepatocellular carcinoma, where its high expression correlates with poor patient prognosis [19]. Similarly, in non-small cell lung cancer,

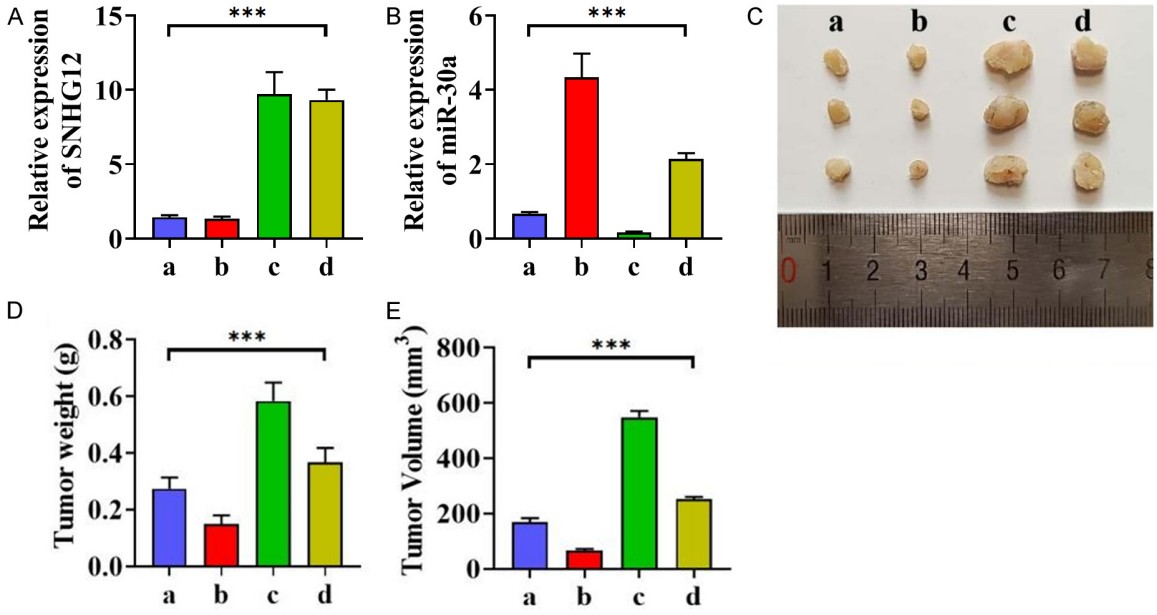

Figure 6. Effect of SNHG12/miR-30a on NPC progression. A: SNHG12 levels in different NPC rat models. B: miR-30a levels in different NPC rat models. C: Macroscopic appearance of tumors in different NPC rat models. D, E: Comparison of tumor weight and volume in different NPC rat models. a: control, b: miR-30a(+), c: SNHG12(+), d: SNHG12(+) miR30a(+), miR-30a: miR-30a-3p. ***$P < 0.001$. n = 3.

SNHG12 is also significantly elevated, promoting cell proliferation and invasion, and its high expression is associated with tumor staging and lymph node metastasis [20]. These studies suggest that SNHG12 could serve as a potential biomarker for multiple cancers. However, SNHG12 expression in NPC remains unclear, and its biological function and molecular mechanisms in NPC progression are yet to be elucidated. In this study, we found that SNHG12 levels are markedly elevated in NPC, with high expression positively correlating with increased tumor volume and lymph node metastasis. Furthermore, silencing SNHG12 expression led to a substantial reduction in CNE-2 cell viability and invasiveness. These findings align with previous reports, such as XX et al. [21], which reported that SNHG12 levels were upregulated in NPC tissues and cell lines, with high expression significantly associated with clinical staging, grading, and poor prognosis.

Our further research indicated that SNHG12 could target and regulate miR-30a. In NPC tissues and cell lines, miR-30a levels were markedly downregulated and showed a significant negative correlation with SNHG12 levels. Additionally, high expression of miR-30a markedly reduced the viability and invasiveness of CNE-2 cells, while SNHG12 inhibited miR-30a levels, counteracting the effects of miR-30a, and enhancing CNE-2 cell activity and migration. Moreover, miR-30a was shown to suppress the invasion and metastasis of renal cancer cells by targeting ATG12 [22]. In hepatocellular carcinoma, miR-30a inhibited cell proliferation by mediating ADAMTS14 [23]. These results highlight the importance of miR-30a in suppressing tumor progression, while SNHG12 appears to regulate miR-30a expression in NPC. Therefore, SNHG12 may serve as a potential metastasis suppressor in NPC.

As an important signaling molecule, AKT3 aberrant activation is closely linked to tumor progression, metastasis, and drug resistance. Research indicates that AKT3 can be activated via the PI3K pathway [24], leading to the phosphorylation of various substrates, including mTOR, GXP4, and FOXO [25-27], thereby regulating cell growth, metabolism, and survival. AKT3 is upregulated in several cancers, such as breast and colorectal cancer [28, 29]. In this study, to explore the potential mechanisms by which SNHG12 promotes NPC progression, we assessed the levels of AKT3 signaling-related markers using PCR and immuno-

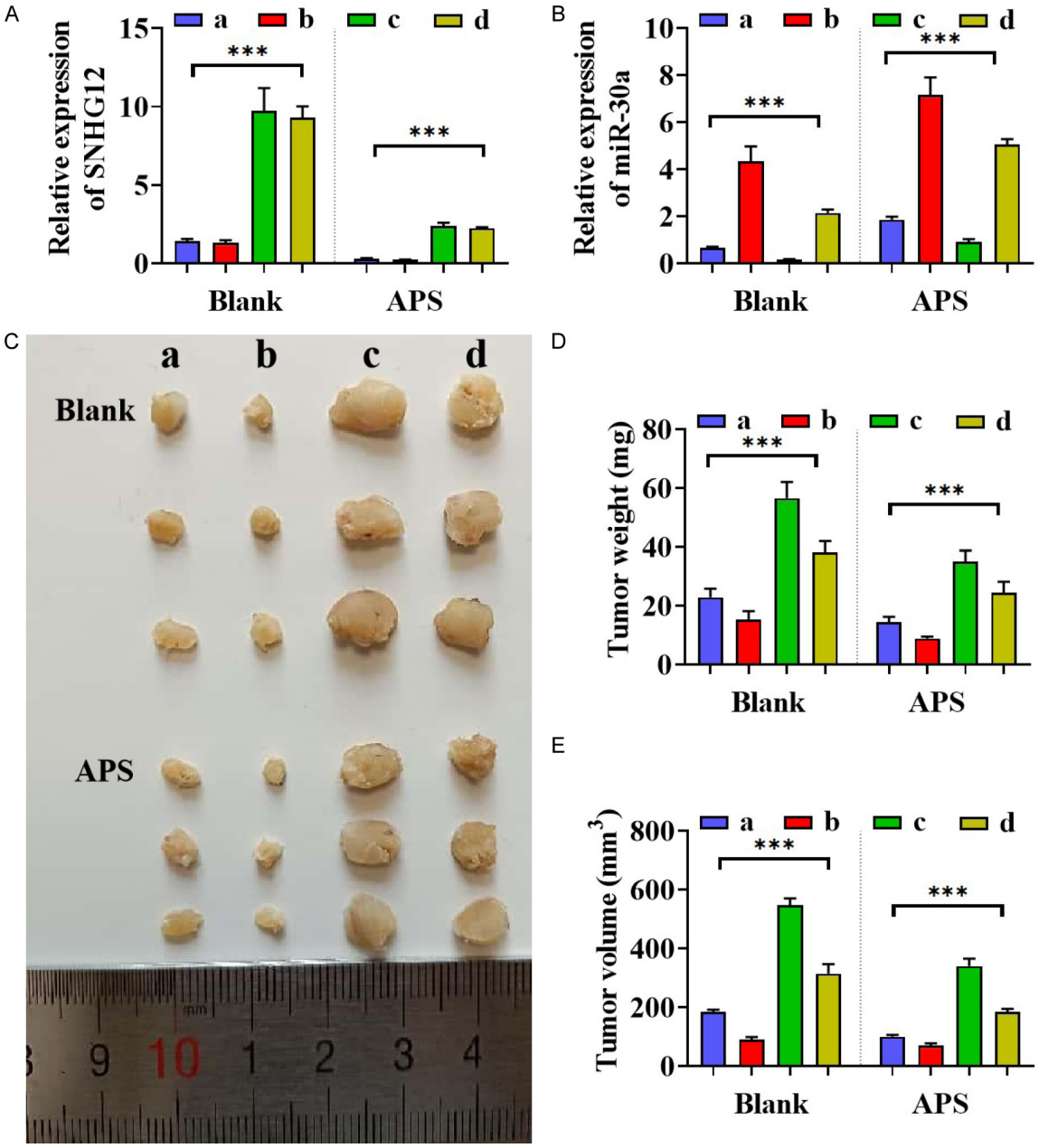

Figure 7. Effect of APS on NPC progression. A: Effect of APS on SNHG12 levels. B: Effect of APS on miR-30a levels. C: Macroscopic appearance of tumors in different NPC rat models. D, E: Effect of APS on tumor weight and volume. a: control, b: miR-30a(+), c: SNHG12(+), d: SNHG12(+)miR30a(+), miR-30a: miR-30a-3p, APS: astragalus polysaccharides, NPC: nasopharyngeal carcinoma. ***$P < 0.001$. Blank, n = 3; APS, n = 3.

fluorescence. Our results revealed that high SNHG12 expression markedly increased the levels of AKT3 and mTOR, while counteracting the inhibitory effects of miR-30a on AKT3 expression. Our findings suggest that SNHG12 may promote NPC progression by mediating the regulation of the AKT3/mTOR signaling pathway through miR-30a.

Through animal experiments, we further confirmed that high expression of SNHG12 effectively promoted NPC proliferation and counteracted the anticancer effects of miR-30a. Subsequently, to evaluate the anticancer effects and mechanisms of APS, we administered APS to NPC rats for 14 consecutive days. The results showed that APS markedly reduced SNHG12

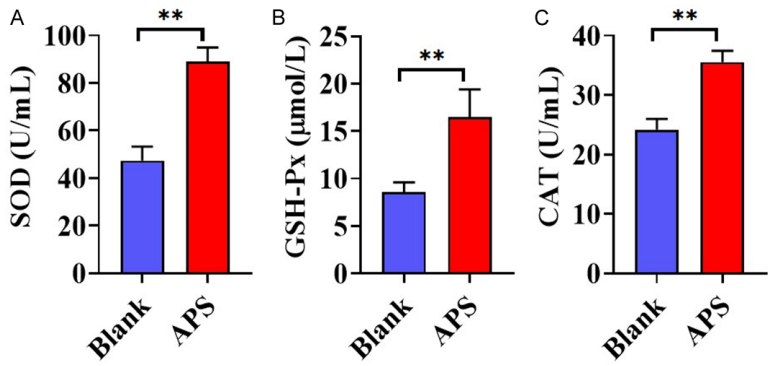

Figure 8. Comparison of SOD (A), GSH-Px (B), and CAT (C) in NPC rat models treated with saline or APS. SOD: superoxide dismutase; GSH-Px: glutathione peroxidase; CAT: catalase, NPC: nasopharyngeal carcinoma, APS: astragalus polysaccharides. $^{**}P < 0.01$. Blank, n = 3; APS, n = 3.

levels in tumor tissues while increasing miR-30a levels, leading to a notable decrease in both the volume and weight of tumors across all groups. These findings suggest that APS may act as an inhibitor of SNHG12, thereby suppressing the SNHG12/miR-30a/AKT3 axis and inhibiting NPC progression. Additionally, previous research indicated that APS exhibited significant antioxidant capabilities, effectively reducing oxidative stress levels within tumor cells. This protective effect helps prevent oxidative damage to normal cells [30]. Moreover, increased oxidative stress within tumor tissues can create a more favorable growth environment for NPC cells, especially in hypoxic and nutrient-deficient tumor microenvironments [31]. The strong antioxidant properties of APS can effectively hinder the malignant expansion of cancer cells [32]. Therefore, APS may inhibit NPC progression by mediating the SNHG12/miR-30a/AKT3 axis and suppressing oxidative stress responses.

In this study, there are several limitations. First, the sample size was relatively small, which may affect the representativeness and statistical significance of the results. Second, the impact of APS on the biological properties of NPC cells at the cellular level was not explored in depth. Finally, the study did not consider the antitumor effects of APS at different concentrations, as variations in concentration may significantly influence their biological activity. This lack of systematic investigation limits their clinical application potential. Therefore, future research should aim to expand the sample size, delve into cellular mechanism studies, and explore the concentration-dependent effects of APS to more comprehensively evaluate their antitumor efficacy.

Conclusion

In summary, SNHG12 targets and inhibits miR-30a, thereby activating the AKT3/mTOR signaling pathway, which promotes malignant biological characteristics of NPC, including enhanced activity and invasiveness. Meanwhile, APS effectively reduces SNHG12 levels in NPC, increases miR-30a levels, and exerts antioxidant effects, thereby inhibiting NPC progression.

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Disclosure of conflict of interest

None.

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