European Review for Medical and Pharmacological Sciences 2020; 24: 9880-9888

SNHG1 promotes proliferation, invasion and EMT of prostate cancer cells through miR-195-5p

X.-F. MENG[1], A.-D. LIU[2], S.-L. LI[3]

[1]Department of Urology, Zoucheng People's Hospital, Shandong, P.R. China
[2]Department of Urology, Linyi People's Hospital, Shandong, P.R. China
[3]Department of Urology, The Fifth People's Hospital of Jinan, Shandong, P.R. China

Abstract. – OBJECTIVE: To explore the correlation of SNHG1 with miR-195-5p, and the mechanism of SNHG1 in prostate cancer (PC).

PATIENTS AND METHODS: The prostate cancer patients admitted to our hospital were selected, and the cancer tissues (n=142) and adjacent tissues (n=142) of the patients were collected during the operation. The content of SNHG1 and miR-195-5p in PC was observed, and the PC cell lines were transfected to detect the proliferation, invasion, apoptosis and Epithelial-Mesenchymal Transitions (EMT) capability.

RESULTS: SNHG1 was enhanced in PC, while miR-195-5p was decreased ($p<0.05$). After transfection of DU-145 and PC-3, it was found that silence of SNHG1 or overexpression of miR-195-5p could evidently inhibit the proliferation and invasion, increase the apoptosis ($p<0.05$). After detecting the EMT markers, it was found that after silencing SNHG1 or over-expressing miR-195-5p, E-cadherin enhanced while N-cadherin and Vimentin reduced ($p<0.05$). Double Luciferase reports confirmed that SNHG1 could act as a sponge to regulate miR-195-5p, and correlation analysis showed that SNHG1 had a negative correlation with miR-195-5p. Rescue experiments found that si-SNHG1 co-transfected with miR-195-5p-inhibitor could reverse the inhibitory role of si-SNHG1 on prostate cancer cells.

CONCLUSIONS: SNHG1 can mediate the proliferation, invasion and EMT of PC by regulating miR-195-5p expression.

Key Words:
SNHG1, MiR-195-5p, Prostate cancer, Proliferation, Invasion, EMT.

Introduction

Prostate cancer (PC) is a common malignant neoplasm of men's reproductive system. In USA, PC is the second leading cause of male cancer death after lung cancer, and it is also estimated that about 31,620 deaths are caused by PC[1,2]. In China, with the changes of social environment and lifestyle, the incidence of PC has gradually up-regulated, and its mortality rate has been the highest among urological tumors[3]. At present, the mechanism of the incidence and development of PC has not been fully clarified, and there is still a lack of sustained and effective treatment strategies, which seriously threatens the physical and mental health of male patients in China[4]. Therefore, determining the molecular mechanism of the incidence and development of PC and exploring its influencing factors will lay a foundation for further proposing new strategies for the treatment of PC.

In recent years, as the change of expression level of RNA (long non-coding RNA, LncRNA) has a close correlation with the incidence and development of neoplasm, the exploration of LncRNA has become a hot spot in clinical research[5]. Although LncRNA is unable to encode proteins, it has complex biological functions. Its transcript length exceeds 200 nucleotides, which can regulate gene expression level in the form of RNA[6,7]. LncRNA-SNHG1 is located at 11q12.3 and participates in the biological behaviors of various tumors[8]. SNHG1 is abnormal in glioma cells, can promote the proliferation and invasion, and reduce the apoptosis[9]. Cui et al[10] found that SNHG1 can promote the growth of PC, and its action pathway is mainly through the regulation of Notch-1. SNHG1 is highly expressed in PC and may be a new target for PC treatment[11]. However, whether SNHG1 can participate in regulating the biological process of prostate cancer still needs more research[12]. Wu et al[13] indicated that miR-195-5p is a new regulator, which can be used to restrain the migration and invasion of PC cells. Li et al[14] have proposed that SNHG1 can accelerate the proliferation of PC by regulating miR-199A-

Corresponding Author: Shunlai Li, MD; e-mail: labanlee@sina.com

3P. Therefore, we speculated that SNHG1 may participate in the biological characteristics of PC cells by regulating miR-195-5p.

This study mainly explored the mechanism of SNHG1 in prostate cancer and the targeted regulatory correlation of SNHG1 with miR-195-5p, providing a new approach for clinical research and treatment.

Patients and Methods

General Information

Altogether 142 cancer tissues and adjacent tissues of prostate cancer patients were collected and placed in liquid nitrogen container. The patients were aged (54.11± 6.12) years. Inclusion criteria: patients were diagnosed as prostate cancer, which met the International Diagnostic Standard[15]; patients with relatively complete clinical data and no mental diseases; patients were accompanied by their family when they admitted to hospital. Exclusion criteria: patients complicated with other malignant tumors or hematological diseases; patients refused to provide experimental specimens; patients with poor compliance. This investigation has been approved by the Ethics Committee of our hospital. The experimental contents were described in detail to subjects and their families, and they have singed complete informed consent forms.

Cell Culture and Transfection

PC cell lines DU-145, LNCaP, 22Rv1, PC-3 and normal human prostate cell line RWPE-1 were obtained from Shanghai Institute of Cellular Biology. The cell lines were put into Dulbecco's Modified Eagle's Medium (DMEM) medium (Gibco, Rockville, MD, USA) containing 10% fetal bovine serum (FBS), cultured at 37°C, with 5% CO_2, digested with 25% pancreatin once every 2 days when the cell adherence growth density reached 80-90%, and then SNHG1 and miR-195-5p were detected. Cell transfection: DU-145 and PC-3 with the greatest difference from normal cell lines were selected for transfection, and Lipofectamine™ 2000 kit (Thermo Fisher Scientific, Waltham, MA, USA) was used for transfection. Targeted inhibition SNHG1(si-SNHG1), blank control (Vector), miR-195-5p-inhibitor, miR-195-5p-mimics and miR-NC were respectively constructed, transfected into cell lines, and cultured in a new culture medium after 6 hours.

Quantitative reverse transcription PCR (qRT-PCR) Detection

Total RNA was extracted by TRIzol (Invitrogen, Carlsbad, CA, USA), and the purity, concentration and integrity were determined by UV spectrophotometer and agarose gel electrophoresis. Reverse transcription was carried out by reverse transcription kit (Invitrogen, Carlsbad, CA, USA), and the operation referred to the kit instructions. The obtained cDNA was applied for later testing. SYBR Premix Ex Taq (TaKaRa, Otsu, Shiga, Japan) was applied for PCR amplification, and GAPDH (for LncRNA) or U6 (for miRNA) was used as internal reference. qRT-PCR reaction was carried out by ABI7500 system (Applied Biosystems, Foster City, CA, USA) under the following reaction conditions: 95°C for 60 s, 95°C for 30 s, 60°C for 40 s, for a total of 40 cycles. The relative expression was determined by $2^{-\Delta\Delta Ct}$. The specific sequence is shown in Table I.

Western Blot (WB) Test

After collecting cells, radio immunoprecipitation assay (RIPA) buffer (Thermo Fisher Scientific Waltham, MA, USA) was applied to obtain total protein, bicinchoninic acid assay (BCA) kit (Thermo Fisher Scientific Waltham, MA, USA) to measure the concentration and quantification, 10% sodium dodecyl sulfate and polyacrylamide gel electrophoresis (SDS-PAGE) to isolate protein. Then, the cells were transferred to polyvinylidene difluoride (PVDF) (Life Technologies, Gaithersburg MD, USA), and 5% skim milk was used, blocked at room temperature, cultured with primary antibody (Abcam, Cambridge, MA,

Table I. Primer sequences.

	Upstream	Downstream
SNHG1	5'-AGGCTGAAGTTACAGGTC-3'	5'-TTGGCTCCCAGTGTCTTA-3'
GAPDH	5'-GTCAACGGATTTGGTCTGTATT-3'	5'-AGTCTTCTGGGTGGCAGTGAT-3'
miR-195-5p	5'-ACACTCCAGCTGGGTAGCAGCACAGAAAT-3'	5'-TGGTGTCGTGGAGTCG-3'
U6	5'-CTCGCTTCGGCAGCACA-3'	5'-AACGCTTCACGAATTTGCGT-3'

USA) at 4°C for one night, rinsed to remove primary antibody. The horseradish peroxidase (HRP) labeled goat anti-rabbit secondary antibody (Abcam, Cambridge, MA, USA) was added, incubated at 37°C for 1-2 h, and developed with enhanced chemiluminescence (ECL) hypersensitivity luminescent liquid. The band was analyzed at the end.

Cell Proliferation Detection

The thiazolyl blue tetrazolium bromide (MTT) assay (Sigma-Aldrich, St. Louis, MO, USA) was used to evaluate cell growth. The transfected cells were incubated with 20 μl of MTT solution in fresh medium for 4 h, 150 μl of dimethyl sulfoxide (DMSO) was added after the supernatant was removed, and the cells were placed in an incubator (37°C, 5% CO_2). Then, the absorbance was measured at 450 nm using a Multiskan GO full wavelength microplate reader (Thermo Fisher Scientific, China) to detect cell proliferation.

Cell Invasion Detection

Invasion was detected by transwell Matrigel (BD Biosciences, Franklin Lakes, NJ, USA). Cells were plated in 6-well plates, collected after transfection, and counted after resuspension with serum-free culture solution. The upper chamber of transwell chamber was covered with Matrigel (BD Biosciences, Franklin Lakes, NJ, USA) glue, then 0. 2 ml suspension (about 4×10^5 cells) was put into the upper chamber, placed in 24-well plate, and 0. 6 ml serum including culture solution was put into 24-well plate. After incubation for 24 h, the cell was collected, fixed, dyed with 0.1% crystal violet, dried, and the cell invasion was observed with a microscope.

Cell Apoptosis Detection

The cells were detected by Annexin V-FITC/P (BD Biosciences) and washed twice with phosphate-buffered saline (PBS), and 100 μL binding buffer was put in. AnnexinV-FITC and propidium iodide (PI) staining were sequentially added and incubated in the dark at room temperature. FACScan (Becton Dickinson, Franklin Lakes, NJ, USA) was applied for analysis.

Double Luciferase Assay

TargetScan was applied to determine the binding sites of SNHG1 and miR-195-5p. SNHG1 was cloned into pmirGLO by Lipofectamine™ 2000 kit. SNHG1-3'UTR Wt and SNHG1-3'UTR Mutant were respectively established and transferred to the downstream of Luciferase reporter gene to sequence and identify the constructed plasmid. Then, the plasmids with correct sequencing were co-transfected into cells. After 48h, the plasmids were analyzed by double Luciferase reporter system (DLR® (Promega, Madison, WI, USA).

Statistical Analysis

SPSS 18.0 (SPSS, Chicago, IL, USA) was used for data analysis and GraphPad 7 was used to visualize the required pictures. The *t*-test was applied for comparison between the two groups, ANOVA for analyzing the differences among multiple groups, LSD-*t* test for backtesting. Pearson test was applied for correlation analysis. $p<0.05$, there was a statistical difference.

Results

SNHG1 and MiR-195-5p In PC

In this study, qRT-PCR was applied to detect the tissues in PC. The results are shown in Figure 1. It could be seen that SNHG1 was enhanced in PC, and miR-195-5p was reduced ($p<0.05$). Subsequently, SNHG1 and miR-195-5p in PC were detected, and SNHG1 in PC cell lines was evidently higher than that in normal prostate cell line RWPE-1, while miR-195-5p in four PC cell lines was evidently lower than that in cell line RWPE-1.

Effects of SNHG1 on Proliferation, Invasion and Epithelial-Mesenchymal Transitions (EMT) of PC

DU-145 and PC-3 cell lines were transfected, as shown in Figure 2. We could see that, after transfection, compared with Vector, SNHG1 in si-SNHG1 group decreased evidently ($p<0.05$), and the proliferation and invasion were evidently inhibited. The apoptosis was significantly accelerated ($p<0.05$). We detected the role of transfected si-SNHG1 on EMT markers in DU-145 and PC-3 cells by WB and found that E-cadherin was increased while N-cadherin and Vimentin were reduced ($p<0.05$).

Effect of MiR-195-5p on Proliferation, Invasion and EMT of PC Cells

PC cell lines were transfected with miR-195-5p mimetic or miR-NC. The content of miR-195-5p in different groups was detected, as shown in

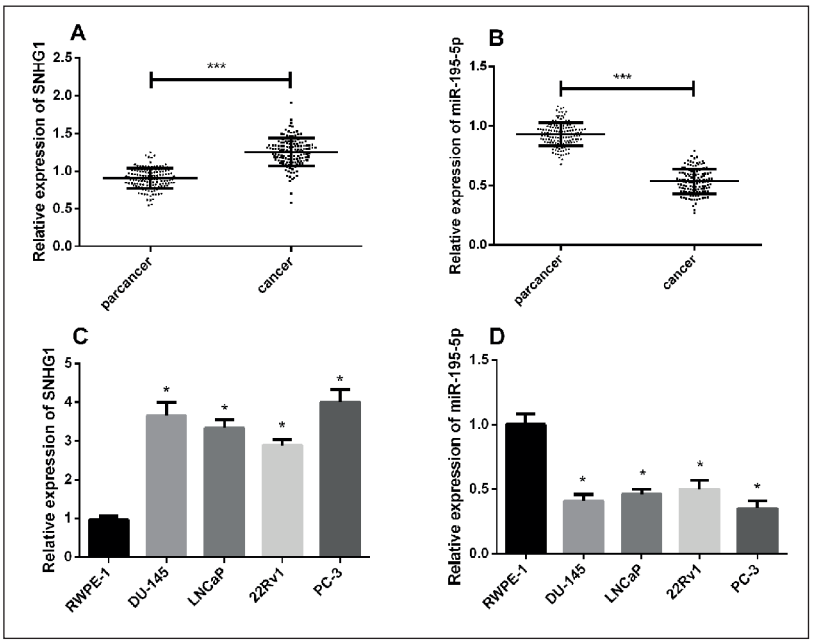

Figure 1. Expression of SNHG1 and miR-195-5p in prostate cancer. **A**, Expression of SNHG1 in prostate cancer tissue. **B**, Expression of miR-195-5p in prostate cancer tissue. **C**, Expression of SNHG1 in prostate cancer cell line. **D**, Expression of miR-195-5p in prostate cancer cell line. Note: * indicates comparison between the two groups or compared with RWPE-1, *indicates that $p<0.05$, *** indicates that $p<0.001$.

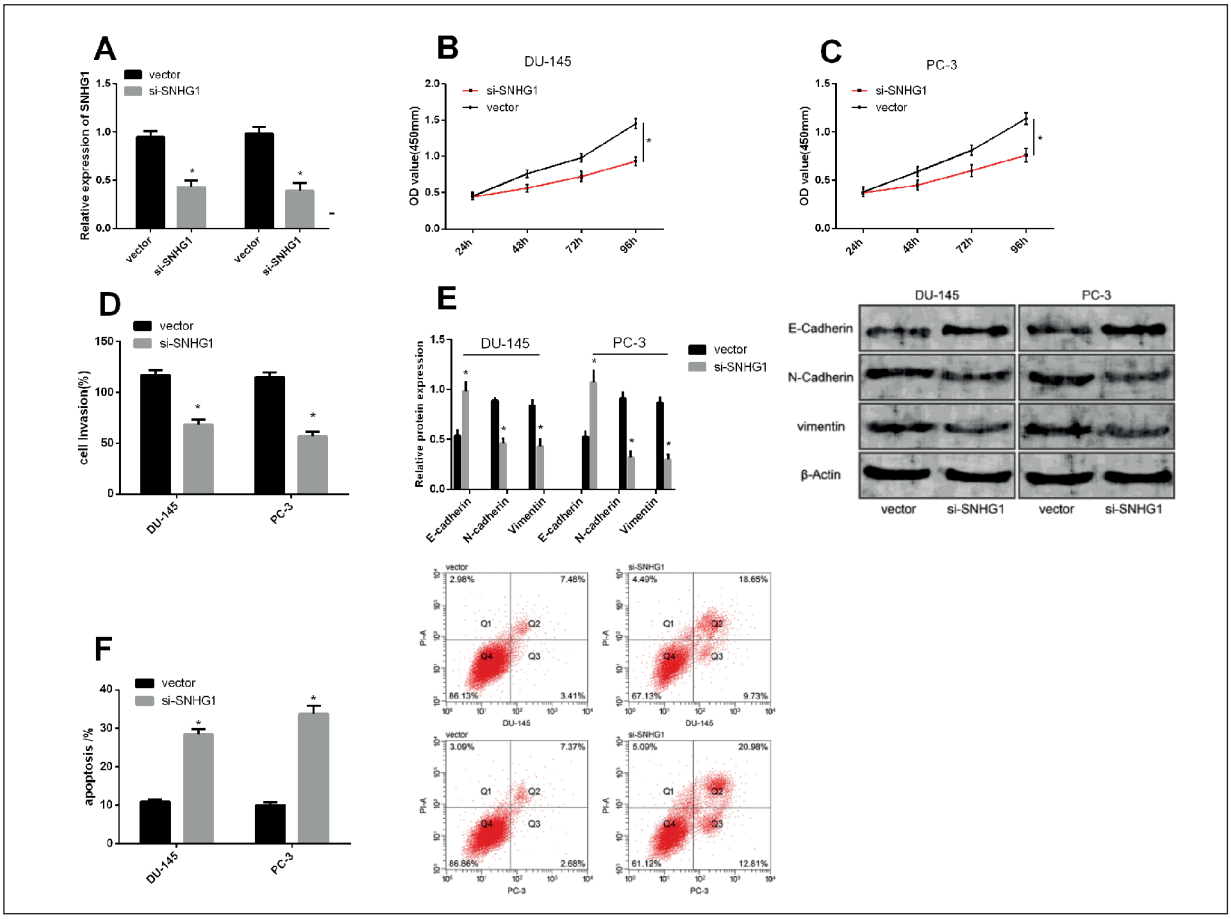

Figure 2. Effect of SNHG1 on proliferation, invasion and EMT behavior of prostate cancer cells. **A**, Effect on SNHG1 expression after different transfection. **B**, Effect of transfection on proliferation of DU-145 cells. **C**, Effect of transfection on proliferation of cell PC-3. **D**, Effect of transfection on cell invasion. **E**, Effect of transfection on EMT markers and protein map. **F**, Effect of transfection on cell apoptosis and apoptosis map. Note: *indicates comparison between the two groups or compared with vector, $p<0.05$.

Figure 3. It could be seen that miR-195-5p was enhanced in miR-195-5p-mimics group and reduced in miR-195-5p-inhibitor group compared with miR-NC group ($p < 0.05$). Further detection of cell biological behavior indicated that the proliferation and invasion of PC cells transfected with miR-195-5p-mimics decreased significantly, the apoptosis rate increased ($p<0.05$), EMT marker E-cadherin increased, and N-cadherin and Vimentin decreased ($p<0.05$). However, miR-195-5p-inhibitor transfected cell groups showed the opposite results.

Targeting Correlation of SNHG1 With MiR-195-5p

Bioinformatics starBase.2.0 has been carried out to explore a targeted binding site of SNHG1 with miR-195-5p, and Luciferase reporter gene has been carried out. The results were shown in Figure 4. Transfection of miR-195-5p-mimics could inhibit SNHG1-3'UT Wt Luciferase activity but would not affect SNHG1-3'UTR Mut Luciferase activity, which indicated that miR-195-5p can play the role of a target gene for SNHG1. Subsequently, we found that miR-195-5p was evidently increased after transfecting with si-SNHG1 ($p<0.05$). Pearson test analysis showed that SNHG1 and miR-195-5p were negatively correlated in prostate cancer tissues (r=-0.455, $p<0.001$).

Rescue Experiment

To further verify that SNHG1 could affect the biological function of prostate cancer cells by regulating miR-195-5p, si-SNHG1+miR-195-5p-inhibitor was co-transfected into DU-145 and PC-3.

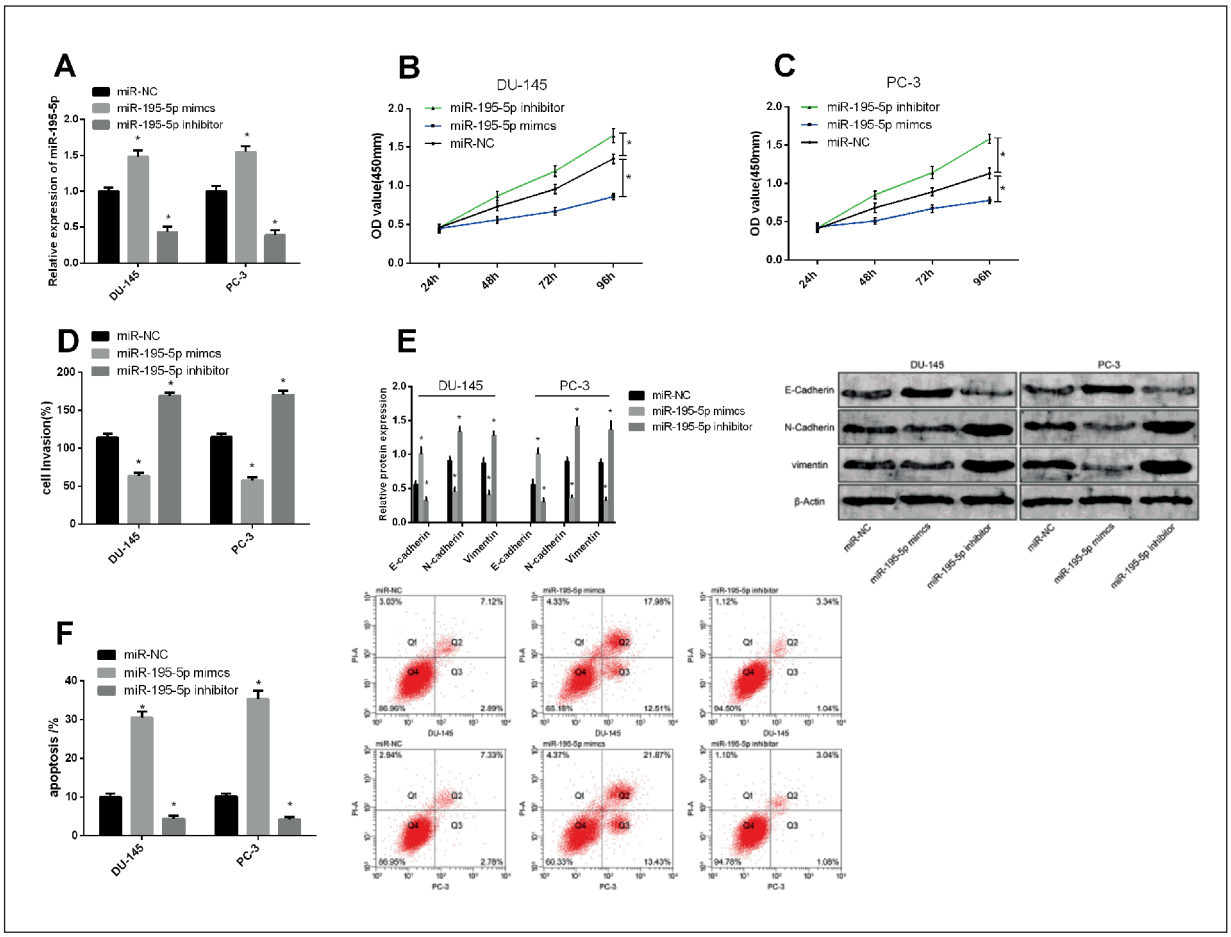

Figure 3. Effect of miR-195-5p on proliferation, invasion and EMT behavior of prostate cancer cells. **A**, Effect on miR-195-5p expression after different transfection. **B**, Effect of transfection on proliferation of DU-145 cells. **C**, Effect of transfection on proliferation of cell PC-3. **D**, Effect of transfection on cell invasion. **E**, Effect of transfection on EMT markers and protein map. **F**, Effect of transfection on cell apoptosis and apoptosis map. Note: * indicates comparison between the two groups or compared with miR-NC, $p<0.05$.

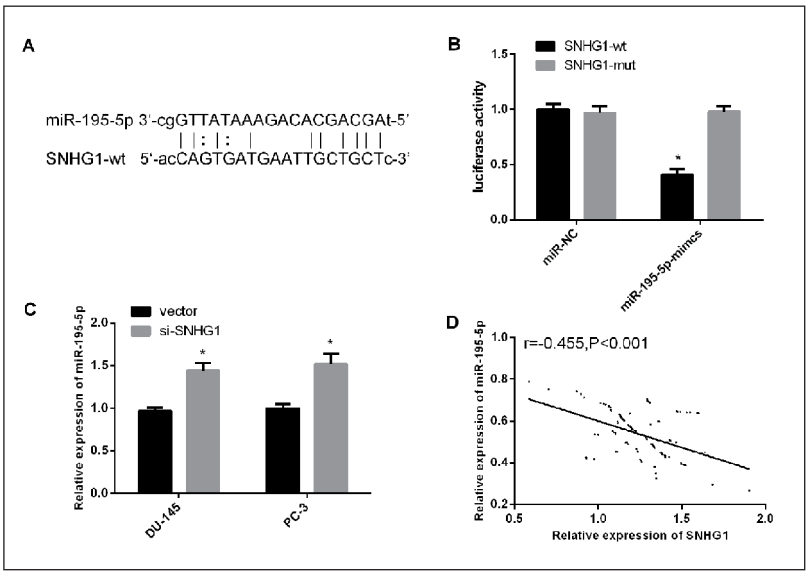

Figure 4. Targeting relationship between SNHG1 and miR-195-5p. **A**, Binding target of SNGH1 and miR-195-5p. **B**, Determination of Luciferase reporter gene. **C**, Effect on miR-195-5p expression after si-SNHG1 transfection. **D**, Correlation between SNHG1 and miR-195-5p in cancer tissue. Note: *indicates that compared with vector, $p<0.05$.

As shown in Figure 5, after si-SNHG1 co-transfecting with miR-195-5p-inhibitor, the cell proliferation, invasion and apoptosis were not evidently different from NC group ($p>0.05$), but the proliferation and invasion ability were enhanced and the apoptosis was reduced compared with cells transfected with si-SNHG1. Then, WB was used to detect the changes of EMT markers in

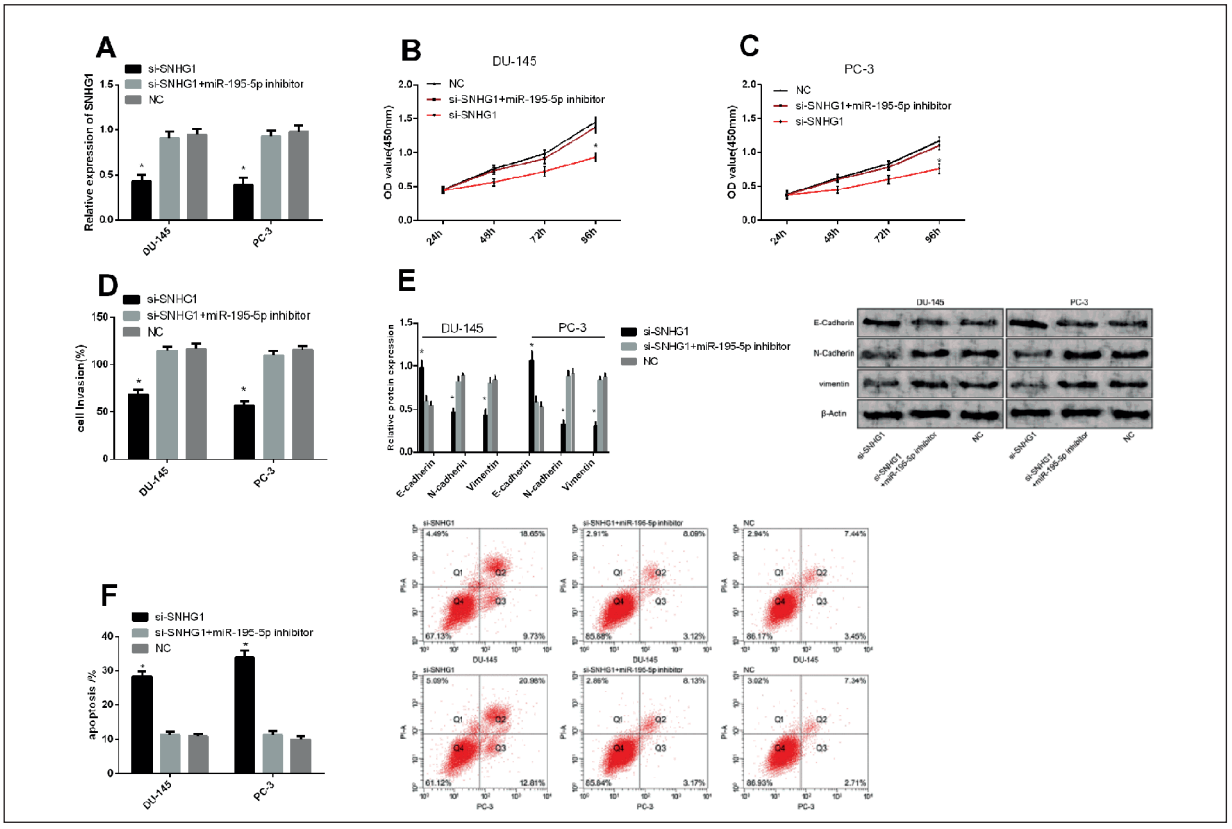

Figure 5. Rescue experiment. **A**, Effect on SNHG1 expression after co-transfection. **B**, Effect of co-transfection on proliferation of DU-145 cells. **C**, Effect of co-transfection on proliferation of cell PC-3. **D**, Effect on cell invasion after co-transfection. **E**, Effect of co-transfection on EMT markers and protein map. **F**, Effect of co-transfection on apoptosis and apoptosis map. Note: *indicates compared that with NC, si-SNHG1+miR-195-5p-inhibitor group, $p<0.05$.

the above groups. It was found that the expression of EMT markers co-transfected by si-SNHG1+miR-195-5p-inhibitor was not evidently different with NC group ($p>0.05$), while E-cadherin decreased, and N-cadherin and Vimentin increased compared with si-SNHG1 cells.

Discussion

The incidence and growth of PC are systemic, and it is involved multiple factors, multiple genes and changes of multiple signal pathways, including abnormal changes of signal transduction genes, oncogenic/tumor suppressor genes, and apoptosis inducing genes[16]. Moreover, due to the lack of effective means for early diagnosis of prostate cancer, it is generally advanced after diagnosis, thus losing the best treatment opportunity and posing a serious threat to the life and health of patients[17]. Therefore, it is of great significance to study the incidence, development and mechanism of PC. LncRNA is mostly placed in the nucleus or cytoplasm and is mainly transcribed by RNA polymerase II. LncRNA regulates chromatin remodeling and regulates transcription and post-transcription genes[18]. There is a correlation of abnormal up-regulation of SNHG1 with late neoplasm stage, neoplasm size and TNM stage, and the survival of PC patients with high SNHG1 is reduced and the prognosis is poor[19].

Through quantitative detection, we found that SNHG1 was evidently increased in PC tissues and cells, suggesting that SNHG1 played a carcinogenic role and participated in the incidence of prostate cancer. Therefore, we further carried out cell experiments. We transfected DU-145 and PC-3 and found that silencing SNHG1 expression can restrain the proliferation and invasion of PC cells and increase the apoptosis rate. Notably, SNHG1 was significantly over-expressed in non-small cell lung cancer (NSCLC)[20], esophageal squamous cell carcinoma (ESCC)[21] and colorectal cancer[22], further proving the promoting effect of SNHG1 in tumors. Besides, Hu et al[23] suggested that SNHG1 could regulate the expression of DNMT1, thus restraining the proliferation of gastric cancer cells.

Silent SNHG1 can act as an anti-tumor *in vitro* and *in vivo* and can effectively reduce the development of breast cancer cells and EMT by regulating miR-382-5p[24]. EMT acts a key initiation role in the process of tumor metastasis, which will cause epithelial cells lose the characteristics and acquire interstitial characteristics, resulting in increased migration and invasion capacity[25]. EMT is involved in the metastatic process of PC, and targeted inhibition of key signaling pathways in EMT has a good effect in tumor treatment[26]. E-cadherin, N-cadherin and Vimentin are markers of EMT, which can effectively reflect the transformation degree of EMT[27]. Therefore, we detected the effect of transfected si-SNHG1 on EMT markers in DU-145 and PC-3 cells by WB and found that silencing SNHG1 can lead to the increase of E-cadherin and the decrease of N-cadherin and Vimentin. Our results suggested that silencing SNHG1 could inhibit EMT effect of prostate cancer cells.

LncRNA can be used as ceRNA to regulate RNA transcripts through competition with miR (microRNA) and promote changes in biological functions of various tumor cells[28,29]. LncRNA GAS5 can act as a sponge to combine with miR-23a, thus promoting the inhibitory role of gastric cancer cell proliferation[30]. LncRNA AFAP1-AS1 can promote PC proliferation and invasion by regulating miR-512-3p[31]. miRNA is a non-coding RNA with 19-23nt, which plays a central role in gene silencing and plays a role as a part of a large gene regulatory network[32].

miR-195 acts as an anti-cancer in PC, reduction of miR-195 could promote the development of tumor cells and could restrain the proliferation and angiogenesis of PC[33]. We found that over-expression of miR-195-5p could significantly restrain the proliferation and invasion of PC, leading to an increase in apoptosis rate, and could inhibit the EMT effect of prostate cancer, while miR-195-5p-inhibitor transfected cell groups showed the opposite results. Previous studies have suggested that miR-195-5p directly regulates NOTCH2 in a post-transcriptional manner by targeting its 3'-UTR, thus participating in the EMT process of colorectal cancer[34]. We found that SNHG1 and miR-195-5p had binding targets through online prediction analysis. The results were verified by double Luciferase report. Correlation analysis indicated that SNHG1 had a negative correlation with miR-195-5p, which indicated that SNHG1 could regulate miR-195-5p. In this paper, a rescue experiment was subsequently carried out. After si-SNHG1 co-transfecting with miR-195-5p-inhibitor, the cell proliferation, invasion, apoptosis and EMT marker were not different from those of NC group. However, compared with the cells transfected with si-SNHG1, the proliferation and invasion ability increased,

and the apoptosis and E-cadherin reduced, and N-cadherin and Vimentin increased. It was suggested that inhibiting miR-195-5p could reverse the anti-cancer effect of silent SNHG1 on prostate cells.

This study firstly showed that SNHG1 regulated the biological behavior of miR-195-5p-mediated cells in prostate cancer and provided some ideas for future clinical treatment. However, there are still some limitations. No research has been conducted on tumor growth in animal models of prostate cancer, and further researches are needed to find out how miR-195-5p participates in EMT process of prostate cancer cells by regulating other relevant targets. Therefore, further research in this direction can be paid attention to in future research.

Conclusions

Shortly, SNHG1 can mediate prostate cancer cell proliferation, invasion and EMT process by regulating miR-195-5p expression.

Conflict of Interest

The Authors declare that they have no conflict of interests.

References

1) Taneja SS. Re: Abiraterone plus prednisone in metastatic, castration-sensitive prostate cancer. J Urol 2018; 199: 26-28.
2) Wang Z, Zhao Y, An Z, Li W. Molecular links between angiogenesis and neuroendocrine phenotypes in prostate cancer progression. Front Oncol 2019; 9: 1491.
3) Gillessen S, Attard G, Beer TM, Beltran H, Bossi A, Bristow R, Carver B, Castellano D, Chung BH, Clarke N, Daugaard G, Davis ID, de Bono J, Borges Dos Reis R, Drake CG, Eeles R, Efstathiou E, Evans CP, Fanti S, Feng F, Fizazi K, Frydenberg M, Gleave M, Halabi S, Heidenreich A, Higano CS, James N, Kantoff P, Kellokumpu-Lehtinen PL, Khauli RB, Kramer G, Logothetis C, Maluf F, Morgans AK, Morris MJ, Mottet N, Murthy V, Oh W, Ost P, Padhani AR, Parker C, Pritchard CC, Roach M, Rubin MA, Ryan C, Saad F, Sartor O, Scher H, Sella A, Shore N, Smith M, Soule H, Sternberg CN, Suzuki H, Sweeney C, Sydes MR, Tannock I, Tombal B, Valdagni R, Wiegel T, Omlin A. Management of patients with advanced prostate cancer: The Report of the Advanced Prostate Cancer Consensus Conference APCCC 2017. Eur Urol 2018; 73: 178-211.
4) Grygorenko VM, Danylets RO, Vikarchuk MV, Gorbahn LV, Klepko AV. Biomarkers of early and differential diagnosis of prostatic cancer. Klin Khir 2017; 54-57.
5) Hubberten M, Bochenek G, Chen H, Häsler R, Wiehe R, Rosenstiel P, Jepsen S, Dommisch H, Schaefer AS. Linear isoforms of the long noncoding RNA CDKN2B-AS1 regulate the c-myc-enhancer binding factor RBMS1. Eur J Hum Genet 2019; 27: 80-89.
6) Okazaki Y, Furuno M, Kasukawa T, Adachi J, Bono H, Kondo S, Nikaido I, Osato N, Saito R, Suzuki H, Yamanaka I, Kiyosawa H, Yagi K, Tomaru Y, Hasegawa Y, Nogami A, Schönbach C, Gojobori T, Baldarelli R, Hill DP, Bult C, Hume DA, Quackenbush J, Schriml LM, Kanapin A, Matsuda H, Batalov S, Beisel KW, Blake JA, Bradt D, Brusic V, Chothia C, Corbani LE, Cousins S, Dalla E, Dragani TA, Fletcher CF, Forrest A, Frazer KS, Gaasterland T, Gariboldi M, Gissi C, Godzik A, Gough J, Grimmond S, Gustincich S, Hirokawa N, Jackson IJ, Jarvis ED, Kanai A, Kawaji H, Kawasawa Y, Kedzierski RM, King BL, Konagaya A, Kurochkin IV, Lee Y, Lenhard B, Lyons PA, Maglott DR, Maltais L, Marchionni L, McKenzie L, Miki H, Nagashima T, Numata K, Okido T, Pavan WJ, Pertea G, Pesole G, Petrovsky N, Pillai R, Pontius JU, Qi D, Ramachandran S, Ravasi T, Reed JC, Reed DJ, Reid J, Ring BZ, Ringwald M, Sandelin A, Schneider C, Semple CA, Setou M, Shimada K, Sultana R, Takenaka Y, Taylor MS, Teasdale RD, Tomita M, Verardo R, Wagner L, Wahlestedt C, Wang Y, Watanabe Y, Wells C, Wilming LG, Wynshaw-Boris A, Yanagisawa M, Yang I, Yang L, Yuan Z, Zavolan M, Zhu Y, Zimmer A, Carninci P, Hayatsu N, Hirozane-Kishikawa T, Konno H, Nakamura M, Sakazume N, Sato K, Shiraki T, Waki K, Kawai J, Aizawa K, Arakawa T, Fukuda S, Hara A, Hashizume W, Imotani K, Ishii Y, Itoh M, Kagawa I, Miyazaki A, Sakai K, Sasaki D, Shibata K, Shinagawa A, Yasunishi A, Yoshino M, Waterston R, Lander ES, Rogers J, Birney E, Hayashizaki Y; FANTOM Consortium; RIKEN Genome Exploration Research Group Phase I & II Team. Analysis of the mouse transcriptome based on functional annotation of 60,770 full-length cDNAs. Nature 2002; 420: 563-573.
7) Miano JM, Long X, Lyu Q. CRISPR links to long noncoding RNA function in mice: A practical approach. Vascul Pharmacol 2019; 114: 1-12.
8) Dong B, Chen X, Zhang Y, Zhu C, Dong Q. The prognostic value of lncRNA SNHG1 in cancer patients: a meta-analysis. BMC Cancer 2019; 19: 780.
9) Wang Q, Li Q, Zhou P, Deng D, Xue L, Shao N, Peng Y, Zhi F. Upregulation of the long non-coding RNA SNHG1 predicts poor prognosis, promotes cell proliferation and invasion, and reduces apoptosis in glioma. Biomed Pharmacother 2017; 91: 906-911.
10) Cui L, Dong Y, Wang X, Zhao X, Kong C, Liu Y, Jiang X, Zhang X. Downregulation of long noncoding RNA SNHG1 inhibits cell proliferation, metastasis, and invasion by suppressing the Notch-1 signaling pathway in pancreatic cancer. J Cell Biochem 2019; 120: 6106-6112.

11) Huang L, Jiang X, Wang Z, Zhong X, Tai S, Cui Y. Small nucleolar RNA host gene 1: A new biomarker and therapeutic target for cancers. Pathol Res Pract 2018; 214: 1247-1252.

12) Tian YJ, Wang YH, Xiao AJ, Li PL, Guo J, Wang TJ, Zhao DJ. Long noncoding RNA SBF2-AS1 act as a ceRNA to modulate cell proliferation via binding with miR-188-5p in acute myeloid leukemia. Artif Cells Nanomed Biotechnol 2019; 47: 1730-1737.

13) Wu J, Ji A, Wang X, Zhu Y, Yu Y, Lin Y, Liu Y, Li S, Liang Z, Xu X, Zheng X, Xie L. MicroRNA-195-5p, a new regulator of Fra-1, suppresses the migration and invasion of prostate cancer cells. J Transl Med 2015; 13: 289.

14) Li J, Zhang Z, Xiong L, Guo C, Jiang T, Zeng L, Li G, Wang J. SNHG1 lncRNA negatively regulates miR-199a-3p to enhance CDK7 expression and promote cell proliferation in prostate cancer. Biochem Biophys Res Commun 2017; 487: 146-152.

15) Egevad L, Delahunt B, Srigley JR, Samaratunga H. International Society of Urological Pathology (ISUP) grading of prostate cancer - An ISUP consensus on contemporary grading. APMIS. 2016;124:433-5.

16) Malik SS, Batool R, Masood N, Yasmin A. Risk factors for prostate cancer: A multifactorial case-control study. Curr Probl Cancer 2018; 42: 337-343.

17) Eapen RS, Nzenza TC, Murphy DG, Hofman MS, Cooperberg M, Lawrentschuk N. PSMA PET applications in the prostate cancer journey: from diagnosis to theranostics. World J Urol 2019; 37: 1255-1261.

18) Bohmdorfer G, Wierzbicki AT. Control of chromatin structure by long noncoding RNA. Trends Cell Biol 2015; 25: 623-632.

19) Thin KZ, Tu JC, Raveendran S. Long non-coding SNHG1 in cancer. Clin Chim Acta 2019; 494: 38-47.

20) Li X, Zheng H. LncRNA SNHG1 influences cell proliferation, migration, invasion, and apoptosis of non-small cell lung cancer cells via the miR-361-3p/FRAT1 axis. Thorac Cancer 2020; 11: 295-304.

21) Luo D, Huang Z, Lv H, Wang Y, Sun W, Sun X. Up-regulation of MicroRNA-21 indicates poor prognosis and promotes cell proliferation in esophageal squamous cell carcinoma via upregulation of lncRNA SNHG1. Cancer Manag Res 2020; 12: 1-14.

22) Bai J, Xu J, Zhao J, Zhang R. lncRNA SNHG1 cooperated with miR-497/miR-195-5p to modify epithelial-mesenchymal transition underlying colorectal cancer exacerbation. J Cell Physiol 2020; 235: 1453-1468.

23) Hu Y, Ma Z, He Y, Liu W, Su Y, Tang Z. LncRNA-SNHG1 contributes to gastric cancer cell proliferation by regulating DNMT1. Biochem Biophys Res Commun 2017; 491: 926-931.

24) Zheng S, Li M, Miao K, Xu H. SNHG1 contributes to proliferation and invasion by regulating miR-382 in breast cancer. Cancer Manag Res 2019; 11: 5589-5598.

25) Nagaraju GP, Long TE, Park W, Landry JC, Taliaferro-Smith L, Farris AB, Diaz R, El-Rayes BF. Heat shock protein 90 promotes epithelial to mesenchymal transition, invasion, and migration in colorectal cancer. Mol Carcinog 2015; 54: 1147-1158.

26) Kolijn K, Verhoef EI, Smid M, Böttcher R, Jenster GW, Debets R, van Leenders GJLH. Epithelial-mesenchymal transition in human prostate cancer demonstrates enhanced immune evasion marked by IDO1 expression. Cancer Res 2018; 78: 4671-4679.

27) Chang J, Hu S, Wang W, Li Y, Zhi W, Lu S, Shi Q, Wang Y, Yang Y. Matrine inhibits prostate cancer via activation of the unfolded protein response/endoplasmic reticulum stress signaling and reversal of epithelial to mesenchymal transition. Mol Med Rep 2018; 18: 945-957.

28) Pilyugin M, Irminger-Finger I. Long non-coding RNA and microRNAs might act in regulating the expression of BARD1 mRNAs. Int J Biochem Cell Biol 2014; 54: 356-367.

29) Fan H, Lv Z, Gan L, Ning C, Li Z, Yang M, Zhang B, Song B, Li G, Tang D, Gao J, Yan S, Wang Y, Liu J, Guo Y. A novel lncRNA regulates the toll-like receptor signaling pathway and related immune function by stabilizing FOS mRNA as a competitive endogenous RNA. Front Immunol 2019; 10: 838.

30) Liu X, Jiao T, Wang Y, Su W, Tang Z, Han C. Liu X, Jiao T, Wang Y, Su W, Tang Z, Han C. Long non-coding RNA GAS5 acts as a molecular sponge to regulate miR-23a in gastric cancer. Minerva Med. 2016 Nov 9. Epub ahead of print.

31) Wang K, Sun H, Sun T, Qu H, Xie Q, Lv H, Hu B. Long non-coding RNA AFAP1-AS1 promotes proliferation and invasion in prostate cancer via targeting miR-512-3p. Gene 2020; 726: 144169.

32) Sun ZQ, Shi K, Zhou QB, Zeng XY, Liu J, Yang SX, Wang QS, Li Z, Wang GX, Song JM, Yuan WT, Wang HJ. MiR-590-3p promotes proliferation and metastasis of colorectal cancer via Hippo pathway. Oncotarget 2017; 8: 58061-58071.

33) Wang X, He C, Yang Z, Li S, Qiao L, Fang L. Dysregulation of long non-coding RNA SNHG12 alters the viability, apoptosis, and autophagy of prostate cancer cells by regulating miR-195/CCNE1 axis. Int J Clin Exp Pathol 2019; 12: 1272-1283.

34) Lin X, Wang S, Sun M, Zhang C, Wei C, Yang C, Dou R, Liu Q, Xiong B. miR-195-5p/NOTCH2-mediated EMT modulates IL-4 secretion in colorectal cancer to affect M2-like TAM polarization. J Hematol Oncol 2019; 12: 20.