Abstract. Propofol is a hypnotic alkylphenol derivative with many biological activities. It is predominantly used in anesthesia and is the most used parenteral anesthetic agent in the United States. Accumulating preclinical studies have shown that this compound may inhibit cancer recurrence and metastasis. Nevertheless, other investigations provided evidence that this compound may promote breast cancer cell progression by modulating different molecular pathways. Clinical data on this topic are scarce and derive from retrospective analyses. For this reason, we reviewed and evaluated the available data to reveal insight into this controversial issue. More preclinical and clinical investigations are necessary to determine the potential role of propofol in the proliferation of breast cancer cells.

Breast cancer is the most widespread malignant tumor affecting women and represents the principal cause of their death worldwide (1). It is characterized by high invasiveness, and surgical resection represents the first line of treatment (2). Unfortunately, after surgery, patients with breast cancer may develop local or distant metastases, which dramatically affects their survival rate (3).

In patients with cancer, the perioperative stress response may lead to the growth of cancer cells and to their dispersal in near or distant organs (4). In this scenario, pharmacological and non-pharmacological agents may play different roles in determining the stress response and, consequently, a potential deviation of the trajectory of the outcome. For instance, many pieces of evidence show that propofol, an alkylphenol derivative general anesthetic used for the induction and maintenance of anesthesia, may affect the long-term outcome of patients with breast cancer (5-7). Several in vitro studies performed on different cancer cell lines showed that due to its anti-inflammatory and anti-oxidative properties, propofol may restrain the expansion of cancer cells through the modulation of different signaling pathways (8). Conversely, because other preclinical studies showed that this compound may promote breast cancer cell progression, the matter remains not completely dissected.

This narrative review aimed to summarize these studies by discussing on the roles of propofol in breast cancer progression and recurrence.

Dissecting the Effects of Propofol on Tumor Cell Proliferation. Propofol (2, 6-diisopropylphenol) is largely used in general anesthesia, including in the setting of oncological surgery. Interestingly, recent studies featured the potential anticancer role of this compound in different types of tumors, including pancreatic, colonic, breast, hepatocellular, ovarian and prostate cancer (9-15). These investigations illustrate the molecular signaling pathways underlying the role of propofol in cancer development (16) (Table I). Specifically, as regards breast cancer, it has been
demonstrated that propofol diminished the transient movement of MDA-MB-231 breast tumor cells by reducing the levels of matrix metalloproteinases (MMPs). This effect is mediated by the regulation of the nuclear factor-κB (NF-κB) pathway (17). A comparative role was shown in MKN45 gastric cancer cells, in which their proliferation and invasion were restrained by the up-regulation of micro-RNA-195 (miR-195) and the inactivation of Janus kinase/signal transducer of activation pathways (18). Propofol also reduced ES-2 ovarian cancer cell movement through the up-regulation of miR-9 expression due to the activation of the NF-κB pathway (19). As regards pancreatic cancer, Du et al. found that by inactivating the NF-κB signaling pathway, propofol instigated the chemosensitization of MIAPaCa-2 pancreatic cells to gemcitabine (20). Other evidence showed that propofol suppressed the multiplication of cardia tumor cells by repressing the mitogen-activated protein kinase (MAPK) and extracellular signal-regulated kinase (ERK) signaling pathways (21). Furthermore, it was shown that propofol provoked death of cardia cancer cells by activating the MAPK signaling pathway and by inhibiting the protein kinase B (AKT) pathway (22). In particular, propofol suppressed the migration of A549 lung cancer cells by down-regulating the MMP2, MMP9, and p38 MAPK signaling pathways (23). Finally, propofol inhibited the invasion of LoVo human colorectal neoplastic cells through the down-regulation of MMPs, which in turn, is strictly regulated by ERK1/2 signaling (13). Moreover, it has been demonstrated that the hypoxia pathway, which plays a significant role in cancer progression and the epithelial-to-mesenchymal transition (EMT), is linked to the effects of propofol on cancer development. Specifically, experimental studies

Table I. Molecular signaling pathways underlying the role of propofol in cancer development.

| Cancer type        | Cell line     | Treatment                                               | Signaling pathways                              | Reference |
|--------------------|---------------|---------------------------------------------------------|--------------------------------------------------|-----------|
| Ovarian            | ES-2          | Propofol at 1, 5 and 10 μg/ml for 24 h                  | NFκB ↓, miR-9 ↑                                | 19        |
| Pancreatic         | MIA PaCa-2    | 10-100 μM Propofol or 0.5 M Na₂CO₃ (vehicle control)   | NFκB ↓                                           | 20        |
|                    |               | for 72 h 100 μmol/l per milliliter propofol for 24, 48, 72 h; or 10, 25, 50, 100 μM gemcitabine for 72 h. For combined treatment 50 or 100 μmol/l per milliliter propofol for 24 h, then 10-100 μmol/l gemcitabine for an additional 72 h | | |
| Cardia Cancer cells| MA 10         | Propofol at 12.5, 25 and 50 μM for 24 h                 | MAPK/ERK ↓                                     | 21        |
| Mouse Leydig tumor | A549          | Propofol at 20, 50 and 100 μg/ml for 24 and 48 h       | MAPK ↑, AKT ↓                                   | 22        |
| Lung adenocarcinoma| LOVO          | Propofol at 5 and 8 μg/ml for 24 h                      | ERK1/2 ↓, MMP9 ↓                                | 23        |
| Colonic Cancer cells| MIAPaCa-2; Panc-1 | Propofol at 25, 50, and 100 μM for 8 h | CaMK II ↓, ERK ↓, AKT ↓ | 24 |
| Pancreatic         | Panc-1        | Propofol at 10 μg/ml for 0-72 h                         | ADAM8 ↓                                         | 25        |
| Prostate LNCaP     | PC3, DU145, and 22RV | Propofol at 10 and 50 μg/ml for 8 h | HIF1α ↓, HIF1β ↓ | 26        |
| Prostate           | PC3, DU145, and 22RV | Docetaxel at 0, 6,25, 12.5, 25, 50 and 100 μM; Propofol at 0, 1,25, 2.5, 5, 10, 20, 40, 80, 160, and 320 μM. | | |
| Ovarian            | HO-8910Pm, H0-8910, SKOV-3, OC VACR-3, COC1 and ES-2 | Paclitaxel at 0.01-10 μg/m 0.1-10 μg/ml of propofol for 72 h | SLUG ↑ | 29 |
| Pancreatic         | Panc-1        | Propofol at 1, 5 or 10 μg/ml for 48 h, or 10 μg/ml for 12, 24 or 36 h | miR-21 ↓, SLUG ↓ | 30 |
| Endometrial        | Ishikawa      | Propofol at 2, 4 and 6 μg/ml for 24 h                  | WNT/b-catenin ↓, SOX4 ↓                          | 31        |
| Breast             | MDA-MB-468    | Propofol at 6 μg/ml for 7 h                            | GABA-A receptor ↑                                | 32        |
| Gallbladder        | GBC-SD cells  | Propofol at 0, 10, 20 and 40 μM for 72 h              | NRF2 ↑                                          | 33        |
| Breast             | MDA-MB-231    | Propofol at 2, 5 and 10 μg/ml for 1, 4 and 12 h       | NRF2 ↑, p53 ↑                                   | 34        |
| Breast             | MDA-MB-231    | Propofol at 0, 2, 5 and 10 μg/ml for 24 h             | MMP2 ↑, MMP9 ↓, NFκB ↓                          | 35        |

ADAM8: A disintegrin and metalloproteinase domain-containing protein 8, AKT: protein kinase B; CaMK II: calcium ion/calmodulin-dependent protein kinase class of enzymes; ERK: extracellular signal-regulated kinases; GABA-A: γ-aminobutyric acid type A; HIF: hypoxia-inducible factor; MAPK: mitogen-activated protein kinase; miR: microRNA; MMP: metalloproteinase; NF-κB: nuclear factor-κ-B; NMDA: N-methyl-D-aspartate receptor; NRF2: nuclear factor erythroid 2-related factor 2; SLUG: snail family transcriptional repressor 2; SOX9: SRY-Box Transcription Factor 9; VEGF: vascular endothelial growth factor. ↑ Up-regulated. ↓ Down-regulated.
conducted on pancreatic cancer cells (Miapaca-2 and Panc-1 cells) indicated that propofol impaired the migration of these cells by regulating the expression of the N-methyl-D-aspartate receptor (24). Moreover, Gao et al., showed that propofol, thought the involvement of the hypoxia pathway, reduced the expression of ADAM metalloproteinase domain containing metallopeptidase domain 8 in Panc-1 pancreatic cancer cells (25) and LNCaP prostate cancer cells (26). Finally, in prostate cancer cells, Quian et al. showed that propofol affected the migration of MDA-MB-231 cells by reducing the expression of p53 and lead to multiple and diverse outcomes. This issue needs for additional studies.

Tumor growth-promoting effects. In two different studies, Garib et al. demonstrated that propofol enhanced the migration of MDA-MB-468 cells by regulating the activation of γ-aminobutyric acid type A (32, 45). Another study reported that propofol also increased the proliferation of MDA-MB-231 cells by reducing the expression of p53 through the regulation of the NRF2 signaling pathway (36).

Clinical research on the role of propofol in the outcome of patients with breast cancer. Uniquely in contrast to preclinical examinations, few clinical studies have been conducted on propofol breast development according to Li et al. (46). Moreover, these data come mainly from retrospective analyses. For instance, Enlund et al. carried out a retrospective study on the survival rate of patients subjected to mastectomy for breast cancer who were administered propofol versus those who underwent volatile anesthesia. In this setting, propofol enhanced survival rates or reduced cancer recurrence. Nevertheless, after correcting for confounders, these differences were not statistically significant (6).

The dual role of propofol on breast cancer development: a controversial issue. Distinctive pre-clinical studies have suggested that propofol has opposing effects on breast cancer development by involving diverse genetic signaling pathways (Table I). Discrepancies among studies are not only due to different experimental conditions but also to the heterogeneity of breast cancer itself (35, 36). It is important to underline that although breast cancer is normally identified as a single disease, it includes up to 21 diverse histological subtypes which respond distinctly to treatments identified as a single disease, it includes up to 21 diverse histological subtypes which respond distinctly to treatments.
those of volatile anesthesia in terms of cancer recurrence and overall survival (47). On the other hand, in another retrospective analysis, Lee et al. found that propofol-based TIVA reduced the risk of breast cancer recurrence 5 years after surgery (7). Wingmore et al. also found significantly better long-term survival rates for patients receiving propofol [3, 714 patients, 504 deaths (24%)] compared to patients receiving volatile anesthetics [3, 316 patients, 796 deaths (24%)] following cancer surgery (48). Recently, different results were obtained in a retrospective study in which propofol TIVA was compared with volatile anesthetics in patients subjected to breast cancer surgery. The authors showed that neither propofol nor desflurane affected patient prognosis and survival (49). Similar negative findings were described by Sessler et al. in a recent randomized controlled clinical trial. They demonstrated that regional anesthesia–analgesia (paravertebral block and propofol) did not lower breast cancer recurrence after surgery compared with opioids and volatile anesthesia (sevoflurane) (50).

Altogether, these contrasting results suggest a need for prospective studies to elucidate this controversial issue. The principal aim of such clinical studies is to find a convincing relationship between propofol and breast cancer outcomes. To date, four prospective studies which compared propofol with sevoflurane in patients with breast cancer are available (51-54). Altogether, these studies highlighted the effects of propofol on outcomes of patients subjected to breast cancer surgery. Importantly propofol has also been shown to reduce the development and severity of acute and chronic pain following surgery (55).

Using systems biology, the mechanism of propofol-induced effects on breast cancer cells should be explored through various ‘omics’ technologies, as reported by Wang et al. (56).

### Conclusion

In this narrative review, we dissected the effects of propofol on the development of breast tumors. Propofol may exert its pro- or antitumor activity on breast cancer by regulating different molecular mechanisms that have not been fully elucidated. Moreover, the high heterogeneity of breast cancer may obscure a consistent mechanism of action for propofol. Unexpectedly, in clinical settings, a few reports demonstrated that propofol may advance breast cancer development. Because available clinical data are scarce, these findings

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**Table II. The effects of propofol on breast cancer progression.**

| Breast cancer cell line | Cell line | Effect on breast cancer development, signaling pathways | Reference |
|------------------------|-----------|-----------------------------------------------------|-----------|
| MDA-MB-231             | Propofol at 0, 2, 5 and 10 μg/ml for 24 h | Impairment of migration and invasiveness MMP2 ↓, MMP9 ↓, NF-κB ↓ | 17        |
| MDA-MB-231             | Propofol at 3 to 8 μg/ml 20 to 50 μM for 24 h | Inhibition of cell migration and adhesion, and enhancement of apoptosis Inhibition of migration | 37        |
| MDA-MB-231             | Propofol at 1-10 μg/ml; Bupivacaine at 0.5-100 μg/ml for 6-24 h. | Inhibition of migration and the invasion of breast cancer cell H19 ↓ | 10        |
| MDA-MB-231             | Propofol at 25, 50, and 100 μM for 24 h | Enhancement of the apoptosis of breast cancer cells. Cleaved caspase-3 ↑, p27 ↑, miR-24 ↓ | 39        |
| MCF-7                  | Propofol at 0-10 μM for 6 h | Inhibition of the proliferation, EMT and enhancement of apoptosis of breast cancer cells. miR-21 ↑, p53 ↑, WNT/β-catenin ↓, PI3K/AKT ↓ | 40        |
| MDA-MB-468             | Propofol at 3, 6, 9 mg/l, etomidate at 2, 3, 4 μg/ml, and lidocaine at 1.25, 2.5, 5 μg/ml up to 10 h | Enhancement of migratory activity of tumor cells | 41        |
| MDA-MB-468             | Propofol at 6 μg/ml for 3 h | Enhancement of migration of tumor cells. Activation of GABA-A receptor. Reorganization of the actin cytoskeleton. \[Ca^{2+}\] ↑ | 32        |
| MDA-MB-231             | Propofol at 2, 5 and 10 μg/ml for 1, 4 and 12 h | Increased proliferation, EMT and enhancement of apoptosis of breast cancer cells. miR-21 ↑, p53 ↑, WNT/β-catenin ↓, PI3K/AKT ↓ | 40        |
| MCF-7                  | Propofol at 2, 5 and 10 μg/ml for 1, 4 and 12 h | Increased proliferation, which was at least partially associated with inhibition of expression of p53. | 34        |
| MDA-MB-468             | Propofol at 3, 6, 9 mg/l, etomidate at 2, 3, 4 μg/ml, and lidocaine at 1.25, 2.5, 5 μg/ml up to 10 h | Increased proliferation, EMT and enhancement of apoptosis of breast cancer cells. miR-21 ↑, p53 ↑, WNT/β-catenin ↓, PI3K/AKT ↓ | 40        |
| MCF-7                  | Propofol at 6 μg/ml for 3 h | Increased proliferation, which was involved in activation of the NRF2 pathway | 34        |

DHA: Docosahexaenoic acid; EMT: epithelial–mesenchymal transition; EPA: eicosapentaenoic acid; GABA-A: γ-aminobutyric acid type A; H19: imprinted maternally expressed transcript; miR: microRNA; MMP: metalloproteinase; NET1: neuroepithelial cell-transforming 1; NF-κB: nuclear factor kappa B; NRF2: nuclear factor erythroid 2-related factor 2; PI3K/AKT: phosphoinositide 3-kinase/protein kinase B. ↑ Up-regulated. ↓ Down-regulated.
require further confirmation. Thus, more pre-clinical and clinical investigations are necessary to translate the pre-clinical studies into clinical practice, potentially in order to develop new propofol-based therapies that will improve the outcomes of a patient subjected to breast oncological surgery.

Conflicts of Interest

The Authors declare no conflicts of interest.

Authors’ Contributions

The present article was mainly written by SB, AC and MC. All Authors contributed toward data analysis, drafting and critically revised the paper, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

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References

1 American Cancer Society. Cancer Facts & Figures Atlanta: American Cancer Society 2017. Available at: https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2017/cancer-facts-and-figures-2017.pdf [Last accessed on May 31st, 2021]
2 DeSantis CE, Lin CC, Mariotto AB, Siegel RL, Stein KD, Kramer JL, Alteri R, Robbins AS and Jemal A: Cancer treatment and survivorship statistics, 2014. CA Cancer J Clin 64(4): 252-271, 2014. PMID: 24890451. DOI: 10.3322/caac.21235
3 Rafferty EA, Park JM, Philpotts LE, Poplack SP, Sumkin JH, Halpern EF and Niklason LT: Assessing radiologist performance using combined digital mammography and breast tomosynthesis compared with digital mammography alone: results of a multicenter, multicenter trial. Radiology 266(1): 104-113, 2013. PMID: 23169790. DOI: 10.1148/radiol.12120674
4 Al-Sahaf O, Wang JH, Browne TJ, Cotter TG and Redmond HP: Propofol-based total intravenous anesthesia on recurrence and outcome from cancer surgery: A retrospective analysis. Anesthesiology 252(6): 1037-1043, 2010. PMID: 21107114. DOI: 10.1097/ALN.0b013e3181efc635
5 Wigmore TJ, Mohammed K and Jhanji S: Long-term survival for patients undergoing volatile versus IV anesthesia for cancer surgery: A retrospective analysis. Anesthesiology 124(1): 69-79, 2016. PMID: 26556730. DOI: 10.1097/ALN.0000000000000936
6 Enlund M, Berglund A, Andresson K, Cieck C, Enlund A and Bergkvist L: The choice of anaesthetic—sevoflurane or propofol—and outcome from cancer surgery: a retrospective analysis. Ups J Med Sci 119(3): 251-261, 2014. PMID: 24857018. DOI: 10.3109/03007934.2014.922649
7 Lee JH, Kang SH, Kim Y, Kim HA and Kim BS: Effects of propofol-based total intravenous anesthesia on recurrence and overall survival in patients after modified radical mastectomy: a retrospective study. Korean J Anesthesiol 69(2): 126-132, 2016. PMID: 27066202. DOI: 10.4097/kjae.2016.69.2.126
8 Bimonte S, Cascella M, Giudice A, Bifalco F, Wirz S and Cuomo A: Propofol Effects in Breast Cancer Cell Progression: Evidences from In Vitro Studies. General Anesthesia Research: 147-157, 2021. DOI: 10.1007/978-1-4939-9891-3_9
9 Ou W, Lv J, Zou X, Yao Y, Wu J, Yang J, Wang Z and Ma Y: Propofol inhibits hepatocellular carcinoma growth and invasion through the HMG2-β-mediated Wnt/β-catenin pathway. Exp Ther Med 13(5): 2501-2506, 2017. PMID: 28565871. DOI: 10.3892/etm.2017.4253
10 Eicimovic P, Murray D, Doran P and Buggy DJ: Propofol and bupivacaine in breast cancer cell function in vitro - role of the NET1 gene. Anticancer Res 34(3): 1321-1331, 2014. PMID: 24596379.
11 Cui WY, Liu Y, Zou YQ, Song T and Wang QS: Propofol induces endoplasmic reticulum (ER) stress and apoptosis in lung cancer cell H460. Tumour Biol 35(6): 5213-5217, 2014. PMID: 24510348. DOI: 10.1007/s13277-014-1677-7
12 Wang ZT, Gong HY, Zheng F, Liu DJ and Dong TL: Propofol suppresses proliferation and invasion of pancreatic cancer cells by upregulating microRNA-133a expression. Genet Mol Res 14(3): 7529-7537, 2015. PMID: 26214431. DOI: 10.4238/2015.July.3.28
13 Miao Y, Zhang Y, Wan H, Chen L and Wang F: GABA-receptor agonist, propofol inhibits invasion of colon carcinoma cells. Biomed Pharmacother 64(9): 583-588, 2010. PMID: 20888181. DOI: 10.1016/j.biopha.2010.03.006
14 Zhang YF, Li CS, Zhou Y and Lu XH: Effects of propofol on colon cancer metastasis through STAT3/HOTAIR axis by activating WIF-1 and suppressing Wnt pathway. Cancer Med 9(5): 1842-1854, 2020. PMID: 31953926. DOI: 10.1002/cam4.2840
15 Sun Y, Peng YB, Ye LL, Ma LX, Zou MY and Cheng ZG: Propofol inhibits proliferation and cisplatin resistance in ovarian cancer cells through regulating the microRNA-374a/forkhead box O1 signaling axis. Mol Med Rep 22(3): 2517-2524, 2020. PMID: 32016462. DOI: 10.3892/mmr.2020.10943
16 Gao X, Mi Y, Guo N, Luan J, Xu H, Hu Z, Wang N, Zhang D, Gou X and Xu L: The mechanism of propofol in cancer development: An updated review. Asia Pac J Clin Oncol 16(2): e3-e11, 2020. PMID: 31790936. DOI: 10.1111/ajco.13301
17 Li Q, Zhang L, Han Y, Jiang Z and Wang Q: Propofol reduces MMPs expression by inhibiting NF-κB-xb activity in human MDA-MB-231 cells. Biomed Pharmacother 66(1): 54-59, 2012. PMID: 22648841. DOI: 10.1016/j.biopha.2011.10.006
18 Zhang W, Wang Y, Zhu Z, Zheng Y and Song B: Propofol inhibits proliferation, migration and invasion of gastric cancer cells via regulating microRNA-195. Int J Biol Macromol 184(2): 5485-5492, 2018. PMID: 30171944. DOI: 10.1016/j.ijbiomac.2018.08.173
19 Huang X, Teng Y, Yang H and Ma J: Propofol inhibits invasion and growth of ovarian cancer cells via regulating miR-9-NF-xb signal. Braz J Med Biol Res 49(12): e5717, 2016. PMID: 27982283. DOI: 10.1590/1414-431X20165717
20 Du QH, Xu YB, Zhang MY, Yun P and He CY: Propofol induces apoptosis and increases gemcitabine sensitivity in pancreatic cancer cells in vitro by inhibition of nuclear factor-xb activity. World J Gastroenterol 19(33): 5485-5492, 2013. PMID: 24023491. DOI: 10.3748/wjg.v19.i33.5485
21 Su Z, Liu HL, Qi B and Liu Y: Effects of propofol on proliferation and apoptosis of cardia cancer cells via...
MAPK/ERK signaling pathway. Eur Rev Med Pharmacol Sci 24(1): 428-433, 2020. PMID: 31957857. DOI: 10.26355/eurrev_202001_19942

22 Kang FC, Wang SC, So EC, Chang MM, Wong KL, Cheng KS, Chen YC and Huang BM: Propofol may increase caspase and MAPK pathways, and suppress the Akt pathway to induce apoptosis in MA-10 mouse Leydig tumor cells. Oncol Rep 41(6): 3565-3574, 2019. PMID: 30102349. DOI: 10.3892/or.2019.7129

23 Wu KC, Yang ST, Hsia TC, Yang JS, Chiou SM, Lu CC, Wu RS and Chung JG: Suppression of cell invasion and migration by propofol are involved in down-regulating matrix metalloproteinase-2 and p38 MAPK signaling in A549 human lung adenocarcinoma epithelial cells. Anticancer Res 32(11): 4833-4842, 2012. PMID: 23155249.

24 Chen X, Wu Q, You L, Chen S, Zhu M and Miao C: Propofol attenuates pancreatic cancer malignant potential via inhibition of NMDA receptor. Eur J Pharmacol 795: 150-159, 2017. PMID: 27986626. DOI: 10.1016/j.ejphar.2016.12.017

25 Gao Y, Yu X, Zhang F and Dai J: Propofol inhibits pancreatic cancer progress under hypoxia via ADAM8. J Hepatobiliary Pancreat Sci 26(6): 219-226, 2019. PMID: 30945470. DOI: 10.1002/jbhp.624

26 Tatsumi K, Hirotsu A, Daito H, Matsuyama T, Terada N and Tanaka T: Effect of propofol on androgen receptor activity in prostate cancer cells. Eur J Pharmacol 809: 242-252, 2017. PMID: 28552345. DOI: 10.1016/j.ejphar.2017.05.046

27 Qian J, Shen S, Chen W and Chen N: Propofol reversed hypoxia-induced dcox2a expression in prostate cancer cell lines by preventing epithelial-mesenchymal transition by inhibiting hypoxia-inducible factor 1α. Biomed Res Int 2018: 4174232, 2018. PMID: 29568752. DOI: 10.1155/2018/4174232.

28 Phillips S and Kuperwasser C: SLUG: Critical regulator of epithelial cell identity in breast development and cancer. Cell Adh Migr 8(6): 578-587, 2014. PMID: 25482617. DOI: 10.4161/19336918.2014.972740

29 Wang P, Chen J, Mu LH, Du QH, Niu XH and Zhang MY: Propofol inhibits invasion and enhances paclitaxel-induced apoptosis in ovarian cancer cells through the suppression of the transcription factor slug. Eur Rev Med Pharmacol Sci 17(13): 1722-1729, 2013. PMID: 23852894.

30 Liu Z, Zhang J, Hong G, Quan J, Zhang L and Yu M: Propofol inhibits growth and invasion of pancreatic cancer cells through regulation of the miR-21/Slug signaling pathway. Am J Transl Res 8(10): 4120-4133, 2016. PMID: 27829977.

31 Du Q, Liu J, Zhang X, Zhang X, Zhu H, Wei M and Wang S: Propofol inhibits proliferation, migration, and invasion but promotes apoptosis by regulation of Sox4 in endometrial cancer cells. Braz J Med Biol Res 51(4): e6803, 2018. PMID: 29490000. DOI: 10.1590/1419-431x20176803

32 Garib V, Lang K, Niggemann B, Zänker KS, Brandt L and Dittmar T: Propofol-induced calcium signalling and actin reorganization within breast carcinoma cells. Eur J Anaesthesiol 22(8): 609-615, 2005. PMID: 16119598. DOI: 10.1017/s026502150500102x

33 Zhang L, Wang N, Zhou S, Ye W, Jing G and Zhang M: Propofol induces proliferation and invasion of gallbladder cancer cells through activation of Nrf2. J Exp Clin Cancer Res 31: 66, 2012. PMID: 22901367. DOI: 10.1186/1756-9966-31-66

34 Meng C, Song L, Wang J, Li D, Liu Y and Cui X: Propofol induces proliferation partially via downregulation of p33 protein and promotes migration via activation of the Nrf2 pathway in human breast cancer cell line MDA-MB-231. Oncol Rep 37(2): 841-848, 2017. PMID: 28035403. DOI: 10.3892/or.2016.5332

35 Yang XR, Chang-Claude J, Goode EL, Couch FJ, Nevanlinna H, Milne RL, Gaudet M, Schmidt MK, Broeks A, Cox A, Fasching PA, Hein R, Spurde AB, Blows F, Driver K, Flesch-Janjys D, Heinz J, Sinn P, Vrielink A, Heikkkinen T, Aittomäki K, Heikkilä P, Blomqvist C, Lissowska J, Peplonska B, Canocho S, Figueueroa J, Brinton L, Hall P, Czene K, Humphreys K, Darabi H, Liu J, van ’t Veer LJ, van Leeuwen FE, Andrusil LS, Glendon G, Knight JA, Mulligan AM, O’Malley FP, Weerasooriya N, John EM, Beckmann MW, Hartmann A, Weihbrecht SB, Wachter DL, Jud SM, Loehberg CR, Baglietto L, English DR, Giles GG, McLean CA, Severi G, Lambrechts D, Vandorpe T, Wilkens R, Paridaens R, Smeets A, Neven P, Wilders H, Wang X, Olson JE, Cafoneck R, Frederickson Z, Kosel M, Vachon C, Cramp HE, Connley D, Cross SS, Balasubramanian SP, Reed MW, Dörk T, Bremer M, Meyer A, Karstens JH, Ay A, Park-Simon TW, Hillemanns P, Arias Pérez JL, Menéndez Rodríguez P, Zamora P, Benitez J, Ko YD, Fischer HP, Hamann U, Pesh B, Brüning T, Justenhoven C, Brauch H, Eccles DM, Tapper WJ, Gery SM, Sawyer EJ, Tomlinson IP, Jones A, Kerin M, Miller N, McNerney N, Anton-Culver H, Ziaogas A, Chen CY, Hsiung CN, Wu PE, Yang SL, Yu JC, Chen ST, Hsu GC, Haiman CA, Henderson BE, Le Marchand L, Kolonen LN, Lindblom A, Margolin S, Jakobowka A, Lubinski J, Huzarski T, Byrski T, Gorski B, Gronwald J, Hooning MJ, Hollestelle A, van den Ouweland AM, Jager A, Krieger M, Tanigawa-Linhorst MM, Collé E, Wang-Wohrke S, Pylkäs K, Jukkola-Vuorinen A, Mononen K, Grip M, Hirvikoski P, Wingqvist R, Manermaa A, Kosma VM, Kaupinni J, Kataja V, Auvinen P, Soini Y, Sironen R, Bojesen SE, Ørsted DD, Kaur-Knudsen D, Flyher H, Nordestgaard BG, Holland H, Chenevix-Trench G, Manoukian S, Bartile M, Raduce P, Hancock SE, Hunter DJ, Tamimi R, Sangrajragr J, Brennan P, McKay J, Odefrey F, Gaborieau V, Devilee P, Huijts PE, Tolnaraa R, Seynaeve C, Dite GS, Apicella C, Hopper JL, Hammett F, Tsmitikis H, Smith LD, Southey MC, Humphreys MK, Easton D, Pharoah P, Sherman ME and Garcia-Closas M: Associations of breast cancer risk factors with tumor subtypes: a pooled analysis from the Breast Cancer Association Consortium studies. J Natl Cancer Inst 103(3): 250-263, 2011. PMID: 21191117. DOI: 10.1093/jnci/djq526

36 Dieci MV, Orvieto E, Dominici M, Conte P and Guarneri V: Rare breast cancer subtypes: histological, molecular, and clinical peculiarities. Oncologist 19(8): 805-813, 2014. PMID: 24969162. DOI: 10.1634/theoncologist.2014-0108

37 Siddiqui RA, Zerougua M, Wu M, Castillo A, Harvey K, Zaloga GP and Stillwell W: Anticancer properties of propofol-docosahexaenoate and propofol-eicosapentaenoate on breast cancer cells. Breast Cancer Res 7(5): R645-R654, 2005. PMID: 16816109. DOI: 10.1186/bcr1036

38 Bai JJ, Lin CS, Ye HJ, Guo PP and Wang W: [Propofol suppresses migration and invasion of breast cancer cells by down-regulating H19]. Nan Fang Yi Ke Da Xue Xue Bao 36(9): 1255-1259, 2016. PMID: 27867660.

39 Yu B, Gao W, Zhou H, Miao X, Chang Y, Wang L, Xu M and Ni G: Propofol induces apoptosis of breast cancer cells by downregulation of miR-24 signal pathway. Cancer Biomark 21(3): 513-519, 2018. PMID: 29103019. DOI: 10.3233/CBM-170234
40 Du Q, Zhang X, Zhang X, Wei M, Xu H and Wang S: Propofol inhibits proliferation and epithelial-mesenchymal transition of MCF-7 cells by suppressing miR-21 expression. Artif Cells Nanomed Biotechnol 47(1): 1265-1271, 2019. PMID: 30942630. DOI: 10.1080/21691401.2019.1594000

41 Li R, Huang Y and Lin J: Distinct effects of general anesthetics on lung metastasis mediated by IL-6/JAK/STAT3 pathway in mouse models. Nat Commun 11(1): 642, 2020. PMID: 32005799. DOI: 10.1038/s41467-019-14065-6

42 Deegan CA, Murray D, Doran P, Ecimovic P, Moriarty DC and Buggy DJ: Effect of anaesthetic technique on oestrogen receptor-negative breast cancer cell function in vitro. Br J Anaesth 103(5): 685-690, 2009. PMID: 19776028. DOI: 10.1093/bja/aep261

43 Jaura AI, Flood G, Gallagher HC and Buggy DJ: Differential effects of serum from patients administered distinct anaesthetic techniques on apoptosis in breast cancer cells in vitro: a pilot study. Br J Anaesth 113(Suppl 1): i63-i67, 2014. PMID: 25009196. DOI: 10.1093/bja/aet581

44 Buckley A, McQuaid S, Johnson P and Buggy DJ: Effect of anaesthetic technique on the natural killer cell anti-tumour activity of serum from women undergoing breast cancer surgery: a pilot study. Br J Anaesth 113(Suppl 1): i56-i62, 2014. PMID: 25009196. DOI: 10.1093/bja/aeu200

45 Garib V, Niggemann B, Zänker KS, Brandt L and Kubens BS: Influence of non-volatile anesthetics on the migration behavior of the human breast cancer cell line MDA-MB-468. Acta Anaesthesiol Scand 46(7): 836-844, 2002. PMID: 12139540. DOI: 10.1034/j.1399-6576.2002.460714.x

46 Li R, Liu H, Dilger JP and Lin J: Effect of Propofol on breast Cancer cell, the immune system, and patient outcome. BMC Anesthesiol 18(1): 77, 2018. PMID: 29945542. DOI: 10.1186/s12871-018-0543-3

47 Kim MH, Kim DW, Kim JH, Lee KY, Park S and Yoo YC: Does the type of anesthesia really affect the recurrence-free survival after breast cancer surgery? Oncotarget 8(52): 90477-90487, 2017. PMID: 29163846. DOI: 10.18632/oncotarget.21014

48 Wigmore TJ, Mohammed K and Jhanji S: Long-term survival for patients undergoing volatile versus IV anaesthesia for cancer surgery: A retrospective analysis. Anaesthesiology 124(1): 69-79, 2016. PMID: 26556730. DOI: 10.1097/ALN.0000000000000936

49 Huang VH, Lee MS, Lou YS, Lai HC, Yu IC, Lu CH, Wong CS and Wu ZF: Propofol-based total intravenous anesthesia did not improve survival compared to desflurane anesthesia in breast cancer surgery. PLoS One 14(11): e0224728, 2019. PMID: 31697743. DOI: 10.1371/journal.pone.0224728

50 Sessler DI, Pei L, Huang Y, Fleischmann E, Marhofer P, Kurz A, Mayers DB, Meyer-Treschan TA, Grady M, Tan EY, Ayad S, Mascha EJ, Buggy DJ and Breast Cancer Recurrence Collaboration: Recurrence of breast cancer after regional or general anaesthesia: a randomised controlled trial. Lancet 394(10211): 1807-1815, 2019. PMID: 31645288. DOI: 10.1016/S0140-6736(19)32313-X

51 Subramani S and Poopalalingam R: Bonfils assisted double lumen endobronchial tube placement in an anticipated difficult airway. J Anaesthesiol Clin Pharmacol 30(4): 568-570, 2014. PMID: 25425788. DOI: 10.4103/0970-9185.142867

52 Weng H, Xu ZY, Liu J, Ma D and Liu DS: Placement of the Univent tube without fiberoptic bronchoscope assistance. Anesth Analg 110(2): 508-514, 2010. PMID: 19933530. DOI: 10.1213/ANE.0b013e3181c5ed18

53 Schuepbach R, Grande B, Camen G, Schmidt AR, Fischer H, Sessler DI, Seifert B, Spahn DR and Ruetzler K: Intubation with VivaSight or conventional left-sided double-lumen tubes: a randomized trial. Can J Anaesth 62(7): 762-769, 2015. PMID: 25663254. DOI: 10.1007/s12630-015-0329-8

54 Desmond F, McCormack J, Mulligan N, Stokes M and Buggy DJ: Effect of anaesthetic technique on immune cell infiltration in breast cancer: a follow-up pilot analysis of a prospective, randomised, investigator-masked study. Anticancer Res 35(3): 1311-1319, 2015. PMID: 25750280.

55 Ng QX, Loke W, Yeo WS, Chng KYY and Tan CH: A meta-analysis of the utility of preoperative intravenous paracetamol for post-caesarean analgesia. Medicina (Kaunas) 55(8): 424, 2019. PMID: 31370298. DOI: 10.3390/medicina55080424

56 Wang P, Ng QX, Zhang H, Zhang B, Ong CN and He Y: Metabolic changes behind faster growth and less reproduction of Daphnia similis exposed to low-dose silver nanoparticles. Ecotoxicol Environ Saf 163: 266-273, 2018. PMID: 30056340. DOI: 10.1016/j.ecoenv.2018.07.080