Anat J Obstet Gynecol Res 2025;2(1):8-15

The Importance of Exosomes in Gynecological Diseases

Naci Çine, Hakan Savlı

Kocaeli University Faculty of Medicine, Department of Medical Genetics, Kocaeli, Turkey

Exosomes play significant roles in key functions of the female reproductive system, such as oogenesis, implantation success, embryo development, and proper fertilization. Exosomes are fundamental cell-derived structures involved in facilitating intercellular communication. Functional connectivity between cells is essential for the viability, development, and coordination of the female reproductive system. It has been demonstrated that the information carried by exosomes is crucial for these cooperative biological mechanisms.

Exosomes are formed by encapsulating biological molecules from the cells of origin. With these features, they contribute both to the reorganization of cellular functions and to the collective functioning of cell populations. Additionally, the content of exosomes is used to monitor the diagnostic and therapeutic processes of various gynecological diseases. They contain genetic and proteomic data that can be utilized as biomarkers or therapeutic targets in gynecological cancers and pregnancy-related disorders.

In this context, the roles of exosomes in major female reproductive disorders-including endometriosis, premature ovarian failure, polycystic ovary syndrome, Asherman's syndrome, endometrial cancer, cervical cancer, ovarian cancer, and preeclampsia are reviewed.

Keywords: Exosomes, infertility. women's reproductive diseases

INTRODUCTION

ABSTRACT

Exosomes are extracellular vesicles with a double-layered lipid membrane secreted by cells.1-3 These vesicles typically measure between 30-150 nm in diameter.4 Their contents include RNA molecules, proteins, lipids, and occasionally DNA.5-7 These components regulate various cellular functions mediated by exosomes.8 Based on size, surface markers, biogenesis, and content, three major types of extracellular vesicles are recognized: exosomes.9,10 apoptotic bodies. microvesicles, and Exosomes effective paracrine are regulators of intercellular communication. In recent years, they have been shown to participate in biological functions such as metabolism regulation, cell proliferation, apoptosis, angiogenesis, antigen presentation, inflammation, tumor pathogenesis, tissue repair, and reproduction.11-13 Exosomes are produced through the inward budding of endosomal membranes, forming multivesicular bodies, which later fuse with the plasma membrane to release exosomes.¹⁴ They interact with target cells via ligand-receptor binding or endocytosis.¹⁵ Following this interaction, vesicles are internalized by phagocytosis.^{2,16} Functional protein groups found in exosomes include β-actin, GPI-anchored proteins, heat shock proteins (HSP8, HSP90), tubulin, and tetraspanins such as CD9, CD63, and CD8.17 Under both physiological and pathological conditions, exosomes reflect the molecular characteristics of their donor cells. This makes them valuable prognostic and diagnostic biomarkers.18,19 Exosomes have been found to be secreted from various parts of the female reproductive system, including the fallopian tube epithelium, follicular fluid, endometrium, uterus, and placenta.²⁰⁻²³ Proper reproductive function and successful pregnancy rely heavily on effective intercellular communication. Oggenesis, follicular development, implantation, fertilization, and embryo development are closely tied to maternalembryo cellular interaction during pregnancy.^{13,24,25} Studies have confirmed both direct and indirect roles of exosomes in cellular communication.26-28

Exosomes communicate with recipient cells and thereby transferring their cargo.²⁹⁻³¹ Once exosomes are internalized, they initiate physiological processes by

Address for Correspondence: Naci Çine, Kocaeli University Faculty of Medicine, Department of Medical Genetics, Kocaeli, Turkey E-mail: nacicine@yahoo.com ORCID ID: orcid.org/0000-0001-9063-1073 Received: 26.04.2025 Accepted: 05.05.2025 Publication Date: 29.05.2025

Cite this article as: Cine N, Savli H. The importance of exosomes in gynecological diseases. Anat J Obstet Gynecol Res. 2025;2(1):8-15

Copyright© 2025 The Author. Published by Galenos Publishing House on behalf of National Society of Gynecology and Obstetrics. This is an open access article under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND) International License. delivering bioactive molecules such as coding and noncoding RNAs, proteins, and lipids. These molecules the functions of the recipient cells.32-34 modulate Studies on human and animal models have demonstrated that exosomes are involved in follicular development, oocyte maturation, and embryo formation. They are also known to carry microRNAs (miRNAs) involved in meiotic resumption and ovulation signaling pathways.³⁵ miRNAs are non-coding RNAs composed of 21-24 nucleotides and participate in various biological processes. They regulate oocyte development, follicular growth, implantation, and embryo development by targeting key genes.³⁶ The most commonly affected signaling pathways by miRNAs include Wnt (Wingless), neurotrophin, epidermal growth factor receptor (EGFR), and TGF-B (transforming growth factor-beta) pathways.37-39 Research into the roles of exosomes in reproductive disorders is expanding rapidly. Due to their diagnostic and therapeutic potential, exosomes are anticipated to play an increasingly significant role in future gynecological disease management.40 This review focuses on their implications in polycystic ovary syndrome (PCOS), premature ovarian failure (POF), Asherman's syndrome, endometriosis, endometrial cancer, cervical cancer, ovarian cancer, and preeclampsia.

Polycystic Ovary Syndrome

PCOS is an endocrine disorder characterized by ovulatory dysfunction and hyperandrogenism. Affecting 6-8% of women globally, PCOS is associated with infertility. obesitv. insulin resistance. dvslipidemia. type 2 diabetes, and cardiovascular diseases.41-45 Follicular fluid analyses from PCOS patients revealed increased expression levels of miR-25-3p, miR-126-3p, miR-143-3p, miR-146a-5p, miR-193b-3p, miR-199a-5p, miR-199a-3p, miR-199b-3p, miR-629-5p, miR-4532, miR-4745-3p, and miR-6087. Additionally, elevated levels of miR-10a-5p, miR-18a-3p, miR-20b-5p, miR-23b-3p, miR-98-5p, miR-106a-5p, miR-141-3p, miR-200a-3p, miR-200c-3p, miR-382-5p, miR-483-5p, miR-483-3p, and miR-3911 were observed. Changes in tRNA and piRNA expression patterns were also noted in exosomes derived from PCOS patients.46-48 These miRNA alterations are implicated in the mitogenactivated protein kinase signaling pathway, circadian rhythm regulation, endocytosis, and overall PCOS risk.46-⁴⁸Another study reported increased expression of S100-A9 in the exosomes of PCOS patients.⁴⁹ S100-A9, a calciumbinding protein secreted by ovarian, granulosa, and immune cells, is involved in cell cycle regulation, proliferation, and inflammation.^{50,51} These exosomes were shown to activate the NF-κB signaling pathway in granulosa-like tumor cells and elevate pro-inflammatory factor expression.⁴⁹ This inflammatory mechanism may underlie reproductive dysfunction in PCOS.^{41,49} In addition to their diagnostic value, exosomes may offer therapeutic benefits. For instance, exosomes derived from adipose mesenchymal stem cells (MSCs) alleviated PCOS symptoms by inhibiting apoptosis via miR-323-3p and altering PDCD4 expression.52

Premature Ovarian Failure

POF is an infertilitv disorder characterized bv hypergonadotropism, amenorrhea, and estrogen deficiency due to follicular dysfunction. It affects approximately 1% of women aged 30-39 years.53-55 While its etiology remains unclear, POF is considered a heterogeneous condition influenced by both genetic and environmental factors.56 Recent studies have investigated the therapeutic potential of exosomes in POF. For example, exosomes derived from placenta-derived (PD)-MSCs increased the expression of antioxidant enzymes such as catalase and peroxiredoxin (PRDX1) in ovariectomized rats, improving ovarian function and reducing mitochondrial reactive oxygen species levels. Similarly, human amniotic epithelial cell-derived exosomes containing miR-1246 were found to restore ovarian function in POF mice via modulation of apoptosis- and phosphatidylinositol-related pathways.57 Exosomes derived from various MSCs also improved follicular morphology and suppressed apoptosis through miR-664-5p, targeting p53.58 Another study demonstrated that bone marrow-derived MSC (BMSC) exosomes containing miR-144-5p targeted PTEN, inhibited apoptosis, and improved ovarian function in POF rats.⁵⁹ Collectively, these studies suggest that exosomebased therapy could represent a promising approach for the treatment of POF.

Asherman Syndrome

Asherman syndrome is characterized by intrauterine adhesions caused by trauma, leading to hypomenorrhea and infertility.60 These scar tissues obstruct blastocyst implantation and result in infertility. Although surgical intervention is commonly used to treat this condition, alternative therapeutic strategies are still required.61,62 Recent studies suggest that exosomal therapy could be beneficial in Asherman syndrome. In a rat model, MSCderived exosomes were shown to reduce fibrosis and promote proliferation and vascularization in uterine tissue. Following exosome application, gene expression levels of matrix metalloproteinases MMP-2, MMP-9, proliferating cell nuclear antigen, CD31, and vascular EGFR were increased, while tissue inhibitor of metalloproteinase-2 levels decreased. These findings suggest that exosomes could be promising biomolecules for treating Asherman syndrome.

Endometriosis

Endometriosis is a multifactorial, estrogen-dependent disorder characterized by the presence of endometrial tissue outside the uterine cavity. The main clinical manifestations include pelvic pain and infertility.⁶⁴⁻⁶⁶ Currently, no definitive treatment ensures the complete resolution of symptoms or long-term remission.^{67,68} Exosomes have emerged as both therapeutic agents and biomarkers for understanding the pathophysiology of endometriosis. Some studies have identified novel diagnostic targets, while others suggest therapeutic roles for exosomes.

Exosomes derived from the endometrium have contributed significantly to elucidating the underlying mechanisms of endometriosis. In one study, exosomes isolated from peritoneal fluid samples of patients with endometriosis contained histone type 2-C, PRDX1, inter-a-trypsin inhibitor heavy chain H4, annexin A2, and tubulin α-chain.69 Another study examining tissue and plasma-derived exosomes from endometriosis patients reported significant differences in miRNA and IncRNA profiles. Decreased expression was noted in IncRNAs LINC00293, LINC00929, MEG8, SNHG25, and RP5-898J17.1, while increased expression was observed in LINC00998, NEAT1, PVT1, H19, and RP4-561L24.3. These RNA molecules influence signaling pathways associated with angiogenesis and inflammation.70 Exosomal miRNAs such as miR-130b. miR-145. miR-342. miR-365, miR-425, miR-432, miR-451a, miR-486-5p, miR-505, miR-1908, miR-4488, and miR-6508 have shown significant associations with inflammatory processes in endometriosis.71 A recent study proposed that elevated serum levels of exosomal miR-22-3p and miR-320a could serve as diagnostic markers for endometriosis.72 These findings highlight the potential of exosomes in improving diagnostic accuracy and developing novel treatment approaches. Another essential feature of exosomes is their therapeutic potential. Exosomes from healthy endometrial epithelial cells carry molecules crucial for embryo-endometrial interaction during implantation.⁷² Application of these exosomes in endometriosis models has shown beneficial effects in modulating the ectopic endometrial environment.73-76 Proteins such as focal adhesion kinase and various surface receptors were shown to influence the adhesive and migratory capacities of trophoblast cells via exosomal signaling.77 miRNAs like miR-17, miR-30d, miR-106a, and miR-200c were found to play critical roles in implantation success when transferred by exosomes.^{29,78,80} M2 macrophage-derived exosomes exhibit regenerative properties that may reduce endometriotic lesions. These exosomes, which are underrepresented or altered in patients with endometriosis, contribute to macrophage activation through miR-223.81,82 Wu et al.83 demonstrated that miR-214 suppresses fibrosis and promotes lesion regression. Collectively, these studies suggest that exosomes may modulate immune escape, cell proliferation, angiogenesis, and lesion invasion in endometriosis. Exosomes derived from ectopic or shed endometrial tissue might also induce metaplasia or tissue repair in recipient cells through the miRNAs and specialized proteins they carry.84

Endometrial Cancers

Endometrial cancer is the fourth most common malignancy of the female reproductive system.⁸⁵ While most cases are diagnosed early due to postmenopausal bleeding, approximately 20% are identified at an advanced stage.^{86,87} Surgical procedures, radiotherapy, and chemotherapy are commonly employed in treatment, but these approaches are often insufficient. Therefore, identifying new molecular targets and biomarkers is critical for effective disease management. Exosomes play important roles in the pathogenesis, progression, diagnosis, and potential treatment of endometrial cancer. Communication between endometrial fibroblasts and cancer cells via exosomes has been proposed.88 In one study, exosomes derived from cancer-associated fibroblasts lacked miR-148b, contributing to tumor progression. Under normal conditions, miR-148b suppresses DNA (cytosine-5)-methyltransferase 1, a protein involved in metastasis by promoting epithelial-mesenchymal transition.⁸⁹ The absence of miR-148b in CAF-derived exosomes is believed to drive endometrial cancer progression through this mechanism. Furthermore, exosomes isolated from the plasma of endometrial cancer patients were shown to promote angiogenesis in human umbilical vein endothelial cells by activating the PI3K/AKT/VEGFA signaling pathway.90 miR-320a, which targets hypoxia-inducible factor 1-alpha, normally suppresses VEGFA expression and cell proliferation. However, reduced levels of miR-320a in CAF-derived exosomes may facilitate malignancy in endometrial cancer.91 Exosomes from the serum of PCOS patients have been reported to enhance the migration and invasion of endometrial cancer cells via upregulation of miR-27a-5p, which targets SADM4.92 In another study, 114 dysregulated miRNAs were identified in exosomes isolated from peritoneal lavage fluid of endometrial cancer patients. Notable miRNAs included miR-10b-5p, miR-34b-3p, miR-34c-5p, miR-34c-3p, miR-449b-5p, miR-200b-3p, miR-383-5p, and miR-2110, all of which were proposed as novel biomarkers.93 These studies suggest the potential importance of exosomederived data in endometrial cancer research. Additionally, they indicate that the sample type and cellular origin of exosomes may be critical for accurate diagnosis and effective therapeutic targeting. The biological source of exosomes could influence tumor behavior, highlighting the need for careful evaluation of exosome origin in both research and clinical applications.

Cervical Cancer

Cervical cancer originates from squamocolumnar junction cells of the cervix and is closely associated with the pathogenesis of human papillomavirus infection.94,95 Early diagnosis is crucial for preventing disease progression and improving outcomes.⁹⁶ Consequently, identifying novel biomarkers for early detection is of great clinical significance. Exosomal miRNAs have been shown to play a role in the progression of cervical cancer. Increased expression levels of miR-21, miR-146a, miR-221-3p, miR-222, let-7d-3p, and miR-30d-5p were found in cervical lavage samples and cell lines, while plasma levels of miR-125a-5p were decreased in cervical cancer patients.97-102 Among these, miR-221-3p has been identified as a key regulator of angiogenesis through its modulation of the thrombospondin-2 gene.¹⁰³ These findings support the use of exosomal miRNAs and other molecules as potential diagnostic and therapeutic biomarkers for cervical cancer. Moreover, exosomes derived from cervical cancer cell lines have been found to carry high levels of miRNAs targeting Hedgehog signaling pathway components such as PTCH1, smoothened, frizzled family receptor, sonic hedgehog signaling molecule, Indian hedgehog signaling molecule. This

pathway is implicated in cervical cancer growth, metastasis, invasion, and drug resistanc.¹⁰⁴ Exosome-based analysis of this pathway may help identify novel therapeutic agents that can inhibit Hedgehog signaling and halt disease progression. Ongoing research has also demonstrated the potential of exosomes as therapeutic agents. For example, exosomes enriched with miR-22 have shown a positive effect on radiotherapy efficacy by downregulating MYCBP (c-Myc binding protein) and hTERT (human telomerase reverse transcriptase) gene expression.¹⁰⁵ Given the molecular cargo carried by exosomes, they may hold potential for contributing to both diagnosis and therapy in the management of cervical cancer.

Ovarian Cancer

Ovarian cancer is the most lethal gynecological malignancy and ranks among the most prevalent cancers affecting the female reproductive system.¹⁰⁶ More than 50% of patients are diagnosed at an advanced stage, contributing to a five-year survival rate of less than 50%.85,107 The poor prognosis and guality of life among ovarian cancer patients are partly attributed to the absence of effective early diagnostic tools. Therefore, the development of novel diagnostic and therapeutic strategies is essential for reducing disease incidence and improving outcomes.¹⁰⁸ Exosomes secreted by ovarian cancer cells have been shown to play significant roles in tumor progression, metastasis, and invasion. Exosomal proteins such as TSG101, CD9, CD24, CD44, and CD63 contribute to the development of ovarian cancer by facilitating intercellular communication. Molecules like HSP27, HSP70, and HSP90 are highly expressed in ovarian cancer patients and are involved in disease pathogenesis.¹⁰⁹⁻¹¹³Otherenzymes-suchasaldehydereductase, phosphoglycerate isomerase, fatty acid synthase, PRDX1, and major histocompatibility complex class I and II antigensalso play roles in tumor development and metastasis^{108,114}. In addition to their roles in tumor biology, exosomal proteins are involved in drug resistance. Elevated levels of annexin A3 in exosomes have been linked to increased platinum resistance in ovarian cancer cells.¹¹⁵ Exosomal miRNAs including miR-106a, miR-130a, miR-221, miR-222, miR-433, and miR-591 have also been associated with drug resistance mechanisms.116-120 Exosome-associated miRNAs such as miR-21, miR-184, miR-193b, miR-200a, miR-200b, miR-200c, miR-203, miR-214, and miR-215 have shown potential as diagnostic cancer.112,114,121-123 biomarkers for ovarian Additional miRNAs like miR-25, miR-29b, miR-100, miR-105, miR-150, miR-187, miR-221, and miR-335 are implicated in the development of malignant ovarian tumors.^{112,114,124} Notably, miR-21 has emerged as a critical player in oncogenesis and metastasis in serous ovarian carcinoma, functioning as an oncomiR.¹²⁵ Moreover, exosome-delivered molecules have therapeutic potential. For instance, miR-29c, miR-101, miR-128, miR-182, miR-506, and miR-520d-3p are under investigation as possible treatment targets for ovarian cancer.¹²⁶ Together, these studies suggest that non-coding RNAs and proteins delivered via exosomes may play important roles in the biology, diagnosis, and treatment of ovarian cancer.

Gaining a better understanding of the mechanisms through which exosomes influence ovarian cancer progression could potentially contribute to the development of more effective therapies and improved disease management.

Preeclampsia

Preeclampsia is a hypertensive disorder of pregnancy responsible for 10-15% of all fetal deaths. It is associated with significant maternal and fetal morbidity and typically occurs after the 20th week of gestation. The condition is often characterized by placental hypoxia.¹²⁷⁻¹³⁰ Despite considerable research. the molecular mechanisms underlying preeclampsia remain unclea.131-133 Recent evidence suggests that exosomes released by placental trophoblasts into maternal circulation may contribute to the pathogenesis of preeclampsia.¹³⁴ Hypoxic conditions in the placenta are known to increase the release of exosomes from the syncytiotrophoblast layer.135,136 Therefore, analyzing the contents of PD exosomes is critical for understanding disease pathogenesis and improving diagnostic capabilities. Increased levels of syncytin-a protein involved in the differentiation of syncytiotrophoblasts from villous trophoblasts-have been found in the exosomes of preeclamptic patients. These trophoblasts play a crucial role in remodeling maternal spiral arteries and differentiating vascular endothelial and smooth muscle cells.137-139 Exosomal profiling in preeclamptic patients revealed that miR-23a-3p, miR-125b-2-3p, miR-144-3p, miR-192-5p, miR-205-5p, miR-208a-3p, miR-335-5p, miR-451a, miR-518a-3p, and miR-542-3p were downregulated. In contrast, miR-7a-5p, miR-17-5p, miR-26a-5p, miR-30c-3p, miR-141-3p, miR-199a-3p, miR-221-3p, miR-584-5p, miR-744-5p, and miR-6724-5p were upregulated.140-143

Safety of Exosomes

Exosomes were shown to distribute into all body compartments bypassing blood-brain barrier, blood testis barrier and blood follicle barriers.¹⁴⁴⁻¹⁴⁶ This enables them to be used as diagnostic agents of different diseases as well as direct therapeutic agents and possibly as drug delivery cargos. Specific tissue cell culture exosomes were classified as enhanced exosomes while natural in vivo produced exosomes from stem cells can be classified as naive exosomes.¹⁴⁷ Naive exosomes are mostly obtained from human umblical cord stem cells, human umblical cord blood stem cells, human adipose tissue derived adult MSCs, human BMSC MSCs, human induced pluripotent stem cell derived MSCs.¹⁴⁸ Exosomes were not reported to cause immunologic reactions and can be applied to the area of inflamation.¹⁴⁹ Exosomes were not shown to form teratomas unlike stem cell therapie.¹⁵⁰

Advancements in technology are driving progress in the diagnostic and therapeutic strategies for gynecological diseases. However, new approaches are still needed to address the complexities of these conditions. Research suggests that exosomes offer promising potential in gynecological disorders by providing meaningful insights for diagnosis, treatment, and disease monitoring. In conclusion, exosome-based studies are expected to make

substantial contributions to understanding and managing gynecological diseases, particularly through the identification of novel diagnostic markers, therapeutic targets, and improved patient monitoring strategies.

Footnote

Authorship Contributions

Literature Search: N.Ç., H.S., Writing: N.Ç., H.S.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

- 1. Cocucci E, Racchetti G, Meldolesi J. Shedding microvesicles: artefacts no more. Trends Cell Biol. 2009;19(2):43-51.
- EL Andaloussi S, Mäger I, Breakefield XO, Wood MJ. Extracellular vesicles: biology and emerging therapeutic opportunities. Nat Rev Drug Discov. 2013;12(5):347-357.
- Tannetta D, Dragovic R, Alyahyaei Z, Southcombe J. Extracellular vesicles and reproduction-promotion of successful pregnancy. Cell Mol Immunol. 2014;11(6):548-563.
- György B, Szabó TG, Pásztói M, et al. Membrane vesicles, current state-of-the-art: emerging role of extracellular vesicles. Cell Mol Life Sci. 2011;68(16):2667-2688.
- Valadi H, Ekström K, Bossios A, Sjöstrand M, Lee JJ, Lötvall JO. Exosome-mediated transfer of mRNAs and microRNAs is a novel mechanism of genetic exchange between cells. Nat Cell Biol. 2007;9(6):654-659.
- Simpson RJ, Jensen SS, Lim JW. Proteomic profiling of exosomes: current perspectives. Proteomics. 2008;8(19):4083-4099.
- Subra C, Laulagnier K, Perret B, Record M. Exosome lipidomics unravels lipid sorting at the level of multivesicular bodies. Biochimie. 2007;89(2):205-212.
- Ding S, Zhang J, Dai Q, et al. Cardioprotective effects of exosomes and their potential therapeutic use. Adv Exp Med Biol. 2017;998:163-177.
- Lai CP, Breakefield XO. Role of exosomes/microvesicles in the nervous system and use in emerging therapies. Front Physiol. 2012;3:228.
- Neven KY, Nawrot TS, Bollati V. Extracellular vesicles: how the external and internal environment can shape cell-to-cell communication. Curr Environ Health Rep. 2017;4(1):30-37.
- Rezaie J, Ajezi S, Avci ÇB, et al. Exosomes and their application in biomedical field: difficulties and advantages. Mol Neurobiol. 2018;55(4):3372-3393.
- 12. Kalluri R. The biology and function of exosomes in cancer. J Clin Invest. 2016;126(4):1208-1215.
- Machtinger R, Laurent LC, Baccarelli AA. Extracellular vesicles: roles in gamete maturation, fertilization and embryo implantation. Hum Reprod Update. 2016;22(2):182-193.
- Aghabozorgi AS, Ahangari N, Eftekhaari TE, et al. Circulating exosomal miRNAs in cardiovascular disease pathogenesis: New emerging hopes. J Cell Physiol. 2019;234(12):21796-21809.
- Urbanelli L, Magini A, Buratta S, et al. Signaling pathways in exosomes biogenesis, secretion and fate. Genes (Basel). 2013;4(2):152-170.
- Mathivanan S, Ji H, Simpson RJ. Exosomes: extracellular organelles important in intercellular communication. J Proteomics. 2010;73(10):1907-1920.

- Lee Y, El Andaloussi S, Wood MJ. Exosomes and microvesicles: extracellular vesicles for genetic information transfer and gene therapy. Hum Mol Genet. 2012;21(R1):R125-R134.
- Gould SJ, Raposo G. As we wait: coping with an imperfect nomenclature for extracellular vesicles. J Extracell Vesicles. 2013;2.
- Lötvall J, Hill AF, Hochberg F, et al. Minimal experimental requirements for definition of extracellular vesicles and their functions: a position statement from the International Society for Extracellular Vesicles. J Extracell Vesicles. 2014;3:26913.
- Almiñana C, Corbin E, Tsikis G, Soleilhavoup C, Galio L, Sandra O. 108 characterization of bovine oviductal exosomes from in vivo and in vitro origin. Reprod Fertil Dev 2015;27(1):147.
- Kropp J, Salih SM, Khatib H. Expression of microRNAs in bovine and human pre-implantation embryo culture media. Front Genet. 2014;5:91.
- Kropp J, Khatib H. Characterization of microRNA in bovine in vitro culture media associated with embryo quality and development. J Dairy Sci. 2015;98(9):6552-6563.
- Kropp J, Khatib H. mRNA fragments in in vitro culture media are associated with bovine preimplantation embryonic development. Front Genet. 2015;6:273.
- Ng YH, Rome S, Jalabert A, et al. Endometrial exosomes/ microvesicles in the uterine microenvironment: a new paradigm for embryo-endometrial cross talk at implantation. PLoS One. 2013;8(3):e58502.
- Valipour J, Nashtaei MS, Khosravizadeh Z, et al. Effect of sulforaphane on apoptosis, reactive oxygen species and lipids peroxidation of human sperm during cryopreservation. Cryobiology. 2021;99:122-130.
- da Silveira JC, Veeramachaneni DN, Winger QA, Carnevale EM, Bouma GJ. Cell-secreted vesicles in equine ovarian follicular fluid contain miRNAs and proteins: a possible new form of cell communication within the ovarian follicle. Biol Reprod. 2012;86(3):71.
- Al-Dossary AA, Strehler EE, Martin-Deleon PA. Expression and secretion of plasma membrane Ca2+-ATPase 4a (PMCA4a) during murine estrus: association with oviductal exosomes and uptake in sperm. PLoS One. 2013;8(11):e80181.
- Ruiz-González I, Xu J, Wang X, Burghardt RC, Dunlap KA, Bazer FW. Exosomes, endogenous retroviruses and toll-like receptors: pregnancy recognition in ewes. Reproduction. 2015;149(3):281-291.
- Zhao H, Achreja A, Iessi E, Logozzi M, Mizzoni D, Di Raimo R, Nagrath D, Fais S. The key role of extracellular vesicles in the metastatic process. Biochim Biophys Acta Rev Cancer. 2018;1869(1):64-77.
- Parolini I, Federici C, Raggi C, et al. Microenvironmental pH is a key factor for exosome traffic in tumor cells. J Biol Chem. 2009;284(49):34211-34222.
- Andreola G, Rivoltini L, Castelli C, et al. Induction of lymphocyte apoptosis by tumor cell secretion of FasL-bearing microvesicles. J Exp Med. 2002;195(10):1303-1316.
- Yáñez-Mó M, Siljander PR, Andreu Z, et al. Biological properties of extracellular vesicles and their physiological functions. J Extracell Vesicles. 2015;4:27066.
- Ahmed KA, Xiang J. Mechanisms of cellular communication through intercellular protein transfer. J Cell Mol Med. 2011;15(7):1458-1473.
- Smyth T, Kullberg M, Malik N, Smith-Jones P, Graner MW, Anchordoquy TJ. Biodistribution and delivery efficiency of unmodified tumor-derived exosomes. J Control Release. 2015;199:145-155.
- 35. Ebrahimi R, Bahiraee A, Niazpour F, Emamgholipour S, Meshkani R. The role of microRNAs in the regulation of insulin signaling

pathway with respect to metabolic and mitogenic cascades: a review. J Cell Biochem. 2019;120(12):19290-19309.

- Pasquariello R, Manzoni EFM, Fiandanese N, et al. Implications of miRNA expression pattern in bovine oocytes and follicular fluids for developmental competence. Theriogenology. 2020;145:77-85.
- Boyer A, Goff AK, Boerboom D. WNT signaling in ovarian follicle biology and tumorigenesis. Trends Endocrinol Metab. 2010;21(1):25-32.
- Dissen GA, Garcia-Rudaz C, Ojeda SR. Role of neurotrophic factors in early ovarian development. Semin Reprod Med. 2009;27(1):24-31.
- Ali M, Esfandyari S, Al-Hendy A. Evolving role of microRNAs in uterine fibroid pathogenesis: filling the gap! Fertil Steril. 2020;113(6):1167-1168.
- Conlan RS, Pisano S, Oliveira MI, Ferrari M, Mendes Pinto I. Exosomes as reconfigurable therapeutic systems. Trends Mol Med. 2017;23(7):636-650.
- Rocha AL, Oliveira FR, Azevedo RC, et al. Recent advances in the understanding and management of polycystic ovary syndrome. F1000Res. 2019;8:F1000 Faculty Rev-565.
- Ndefo UA, Eaton A, Green MR. Polycystic ovary syndrome: a review of treatment options with a focus on pharmacological approaches. P T. 2013;38(6):336-355.
- Chugh RM, Park HS, Esfandyari S, Elsharoud A, Ulin M, Al-Hendy A. Mesenchymal stem cell-conditioned media regulate steroidogenesis and inhibit androgen secretion in a PCOS cell model via BMP-2. Int J Mol Sci. 2021;22(17):9184.
- Qu J, Wang Y, Wu X, Gao L, Hou L, Erkkola R. Insulin resistance directly contributes to androgenic potential within ovarian theca cells. Fertil Steril. 2009;91(5 Suppl):1990-1997.
- Rashidi Z, Khosravizadeh Z, Talebi A, Khodamoradi K, Ebrahimi R, Amidi F. Overview of biological effects of Quercetin on ovary. Phytother Res. 2021;35(1):33-49.
- Hu J, Tang T, Zeng Z, Wu J, Tan X, Yan J. The expression of small RNAs in exosomes of follicular fluid altered in human polycystic ovarian syndrome. PeerJ. 2020;8:e8640.
- Thomson T, Lin H. The biogenesis and function of PIWI proteins and piRNAs: progress and prospect. Annu Rev Cell Dev Biol. 2009;25:355-376.
- Jiang X, Li J, Zhang B, et al. Differential expression profile of plasma exosomal microRNAs in women with polycystic ovary syndrome. Fertil Steril. 2021;115(3):782-792.
- Li H, Huang X, Chang X, et al. S100-A9 protein in exosomes derived from follicular fluid promotes inflammation via activation of NF-κB pathway in polycystic ovary syndrome. J Cell Mol Med. 2020;24(1):114-125.
- Adams J, Liu Z, Ren YA, et al. Enhanced inflammatory transcriptome in the granulosa cells of women with polycystic ovarian syndrome. J Clin Endocrinol Metab. 2016;101(9):3459-3468.
- 51. Heizmann CW, Fritz G, Schäfer BW. S100 proteins: structure, functions and pathology. Front Biosci. 2002;7:d1356-d1368.
- Zhao Y, Tao M, Wei M, Du S, Wang H, Wang X. Mesenchymal stem cells derived exosomal miR-323-3p promotes proliferation and inhibits apoptosis of cumulus cells in polycystic ovary syndrome (PCOS). Artif Cells Nanomed Biotechnol. 2019;47(1):3804-3813.
- 53. Zhang C. The roles of different stem cells in premature ovarian failure. Curr Stem Cell Res Ther. 2020;15(6):473-481.
- Esfandyari S. miRNA-144 Increases estrogen-producing genes expression and suppress apoptosis in human granulosa cell line. Fertil. Steril. 2020, 114, e438.
- Chen L, Guo S, Wei C, Li H, Wang H, Xu Y. Effect of stem cell transplantation of premature ovarian failure in animal models and patients: a meta-analysis and case report. Exp Ther Med. 2018;15(5):4105-4118.

- Hoek A, Schoemaker J, Drexhage HA. Premature ovarian failure and ovarian autoimmunity. Endocr Rev. 1997;18(1):107-134.
- 57. Zhang Q, Sun J, Huang Y, et al. Human amniotic epithelial cellderived exosomes restore ovarian function by transferring micrornas against apoptosis. Mol Ther Nucleic Acids. 2019;16:407-418.
- Sun B, Ma Y, Wang F, Hu L, Sun Y. miR-644-5p carried by bone mesenchymal stem cell-derived exosomes targets regulation of p53 to inhibit ovarian granulosa cell apoptosis. Stem Cell Res Ther. 2019;10(1):360.
- Yang M, Lin L, Sha C, et al. Bone marrow mesenchymal stem cell-derived exosomal miR-144-5p improves rat ovarian function after chemotherapy-induced ovarian failure by targeting PTEN. Lab Invest. 2020;100(3):342-352.
- Esfandyari S, Chugh RM, Park HS, Hobeika E, Ulin M, Al-Hendy A. Mesenchymal stem cells as a bio organ for treatment of female infertility. Cells. 2020;9(10):2253.
- Dreisler E, Kjer JJ. Asherman's syndrome: current perspectives on diagnosis and management. Int J Womens Health. 2019;11:191-198.
- 62. March CM. Asherman's syndrome. Semin Reprod Med. 2011;29(2):83-94.
- Saribas GS, Ozogul C, Tiryaki M, Alpaslan Pinarli F, Hamdemir Kilic S. Effects of uterus derived mesenchymal stem cells and their exosomes on asherman's syndrome. Acta Histochem. 2020;122(1):151465.
- 64. Sasson IE, Taylor HS. Stem cells and the pathogenesis of endometriosis. Ann N Y Acad Sci. 2008;1127:106-115.
- Ceccaroni M, Roviglione G, Rosenberg P, et al. Pericardial, pleural and diaphragmatic endometriosis in association with pelvic peritoneal and bowel endometriosis: a case report and review of the literature. Wideochir Inne Tech Maloinwazyjne. 2012;7(2):122-131.
- 66. Khodarahmian M, Amidi F, Moini A, et al. A randomized exploratory trial to assess the effects of resveratrol on VEGF and TNF-α 2 expression in endometriosis women. J Reprod Immunol. 2021;143:103248.
- Maybin JA, Critchley HO. Menstrual physiology: implications for endometrial pathology and beyond. Hum Reprod Update. 2015;21(6):748-761.
- Karamian A, Paktinat S, Esfandyari S, Nazarian H, Ziai SA, Zarnani AH, et al. Pyrvinium pamoate induces in-vitro suppression of IL-6 and IL-8 produced by human endometriotic stromal cells. Hum. Exp. Toxicol. 2020.
- Nazri HM, Imran M, Fischer R, et al. Characterization of exosomes in peritoneal fluid of endometriosis patients. Fertil Steril. 2020;113(2):364-373.
- Khalaj K, Miller JE, Lingegowda H, et al. Extracellular vesicles from endometriosis patients are characterized by a unique miRNA-IncRNA signature. JCI Insight. 2019;4(18):e128846.
- Chen Y, Wang K, Xu Y, et al. Alteration of myeloid-derived suppressor cells, chronic inflammatory cytokines, and exosomal mirna contribute to the peritoneal immune disorder of patients with endometriosis. Reprod Sci. 2019;26(8):1130-1138.
- Zhang L, Li H, Yuan M, Li D, Sun C, Wang G. Serum exosomal microRNAs as potential circulating biomarkers for endometriosis. Dis Markers. 2020;2020:2456340.
- 73. Sharpe-Timms KL. Endometrial anomalies in women with endometriosis. Ann N Y Acad Sci. 2001;943:131-147.
- Pabona JM, Simmen FA, Nikiforov MA, et al. Krüppel-like factor 9 and progesterone receptor coregulation of decidualizing endometrial stromal cells: implications for the pathogenesis of endometriosis. J Clin Endocrinol Metab. 2012;97(3):E376-E392.

- Zelenko Z, Aghajanova L, Irwin JC, Giudice LC. Nuclear receptor, coregulator signaling, and chromatin remodeling pathways suggest involvement of the epigenome in the steroid hormone response of endometrium and abnormalities in endometriosis. Reprod Sci. 2012;19(2):152-162.
- Aghajanova L, Giudice LC. Molecular evidence for differences in endometrium in severe versus mild endometriosis. Reprod Sci. 2011;18(3):229-251.
- Greening DW, Nguyen HP, Elgass K, Simpson RJ, Salamonsen LA. Human endometrial exosomes contain hormone-specific cargo modulating trophoblast adhesive capacity: insights into endometrial-embryo interactions. Biol Reprod. 2016;94(2):38.
- Homer H, Rice GE, Salomon C. Review: embryo- and endometriumderived exosomes and their potential role in assisted reproductive treatments-liquid biopsies for endometrial receptivity. Placenta. 2017;54:89-94.
- Shomali N, Hemmatzadeh M, Yousefzadeh Y, et al. Exosomes: emerging biomarkers and targets in folliculogenesis and endometriosis. J Reprod Immunol. 2020;142:103181.
- Vilella F, Moreno-Moya JM, Balaguer N, et al. Hsa-miR-30d, secreted by the human endometrium, is taken up by the preimplantation embryo and might modify its transcriptome. Development. 2015;142(18):3210-3221.
- Ismail N, Wang Y, Dakhlallah D, et al. Macrophage microvesicles induce macrophage differentiation and miR-223 transfer. Blood. 2013;121(6):984-995.
- Schjenken JE, Panir K, Robertson SA, Hull ML. Exosomemediated intracellular signalling impacts the development of endometriosis-new avenues for endometriosis research. Mol Hum Reprod. 2019;25(1):2-4.
- Wu D, Lu P, Mi X, Miao J. Exosomal miR-214 from endometrial stromal cells inhibits endometriosis fibrosis. Mol Hum Reprod. 2018;24(7):357-365.
- Klemmt PAB, Starzinski-Powitz A. Molecular and cellular pathogenesis of endometriosis. Curr Womens Health Rev. 2018;14(2):106-116.
- Siegel RL, Miller KD, Jemal A. Cancer statistics, 2019. CA Cancer J Clin. 2019;69(1):7-34.
- Leskela S, Pérez-Mies B, Rosa-Rosa JM, et al. Molecular basis of tumor heterogeneity in endometrial carcinosarcoma. Cancers (Basel). 2019;11(7):964.
- Carvalho MJ, Laranjo M, Abrantes AM, Torgal I, Botelho MF, Oliveira CF. Clinical translation for endometrial cancer stem cells hypothesis. Cancer Metastasis Rev. 2015;34(3):401-416.
- Maida Y, Takakura M, Nishiuchi T, Yoshimoto T, Kyo S. Exosomal transfer of functional small RNAs mediates cancerstroma communication in human endometrium. Cancer Med. 2016;5(2):304-314.
- Li BL, Lu W, Qu JJ, Ye L, Du GQ, Wan XP. Loss of exosomal miR-148b from cancer-associated fibroblasts promotes endometrial cancer cell invasion and cancer metastasis. J Cell Physiol. 2019;234(3):2943-2953.
- 90. Song Y, Wang M, Tong H, et al. Plasma exosomes from endometrial cancer patients contain LGALS3BP to promote endometrial cancer progression. Oncogene. 2021;40(3):633-646.
- Zhang N, Wang Y, Liu H, Shen W. Extracellular vesicle encapsulated microRNA-320a inhibits endometrial cancer by suppression of the HIF1α/VEGFA axis. Exp Cell Res. 2020;394(2):112113.
- Che X, Jian F, Chen C, Liu C, Liu G, Feng W. PCOS serumderived exosomal miR-27a-5p stimulates endometrial cancer cells migration and invasion. J Mol Endocrinol. 2020;64(1):1-12.
- Roman-Canal B, Moiola CP, Gatius S, et al. EV-Associated miRNAs from peritoneal lavage are a source of biomarkers in endometrial cancer. Cancers (Basel). 2019;11(6):839.

- Ault KA. Epidemiology and natural history of human papillomavirus infections in the female genital tract. Infect Dis Obstet Gynecol. 2006;2006 Suppl:40470.
- 95. Barchuk A, Bespalov A, Huhtala H, et al. Breast and cervical cancer incidence and mortality trends in Russia 1980-2013. Cancer Epidemiol. 2018;55:73-80.
- Kori M, Yalcin Arga K. Potential biomarkers and therapeutic targets in cervical cancer: Insights from the meta-analysis of transcriptomics data within network biomedicine perspective. PLoS One. 2018;13(7):e0200717.
- Liu J, Sun H, Wang X, et al. Increased exosomal microRNA-21 and microRNA-146a levels in the cervicovaginal lavage specimens of patients with cervical cancer. Int J Mol Sci. 2014;15(1):758-773.
- Zheng M, Hou L, Ma Y, et al. Exosomal let-7d-3p and miR-30d-5p as diagnostic biomarkers for non-invasive screening of cervical cancer and its precursors. Mol Cancer. 2019;18(1):76.
- Lv A, Tu Z, Huang Y, Lu W, Xie B. Circulating exosomal miR-125a-5p as a novel biomarker for cervical cancer. Oncol Lett. 2021;21(1):54.
- Pan ZX, Zhang XY, Chen SR, Li CZ. Upregulated exosomal miR-221/222 promotes cervical cancer via repressing methyl-CpG-binding domain protein 2. Eur Rev Med Pharmacol Sci. 2019;23(9):3645-3653.
- Wu XG, Zhou CF, Zhang YM, et al. Cancer-derived exosomal miR-221-3p promotes angiogenesis by targeting THBS2 in cervical squamous cell carcinoma. Angiogenesis. 2019;22(3):397-410.
- 102. Zhang L, Li H, Yuan M, Li M, Zhang S. Cervical cancer cellssecreted exosomal microRNA-221-3p promotes invasion, migration and angiogenesis of microvascular endothelial cells in cervical cancer by down-regulating MAPK10 expression. Cancer Manag Res. 2019;11:10307-10319.
- Nahand JS, Vandchali NR, Darabi H, et al. Exosomal microRNAs: novel players in cervical cancer. Epigenomics. 2020;12(18):1651-1660.
- Bhat A, Sharma A, Bharti AC. Upstream hedgehog signaling components are exported in exosomes of cervical cancer cell lines. Nanomedicine (Lond). 2018;13(17):2127-2138.
- Konishi H, Hayashi M, Taniguchi K, et al. The therapeutic potential of exosomal miR-22 for cervical cancer radiotherapy. Cancer Biol Ther. 2020;21(12):1128-1135.
- Szajnik M, Czystowska-Kuźmicz M, Elishaev E, Whiteside TL. Biological markers of prognosis, response to therapy and outcome in ovarian carcinoma. Expert Rev Mol Diagn. 2016;16(8):811-826.
- Dorayappan KDP, Wallbillich JJ, Cohn DE, Selvendiran K. The biological significance and clinical applications of exosomes in ovarian cancer. Gynecol Oncol. 2016;142(1):199-205.
- Cheng L, Wu S, Zhang K, Qing Y, Xu T. A comprehensive overview of exosomes in ovarian cancer: emerging biomarkers and therapeutic strategies. J Ovarian Res. 2017;10(1):73.
- Runz S, Keller S, Rupp C, et al. Malignant ascites-derived exosomes of ovarian carcinoma patients contain CD24 and EpCAM. Gynecol Oncol. 2007;107(3):563-571.
- Nakamura K, Sawada K, Kinose Y, et al. Exosomes promote ovarian cancer cell invasion through transfer of CD44 to peritoneal mesothelial cells. Mol Cancer Res. 2017;15(1):78-92.
- 111. Li QL, Bu N, Yu YC, Hua W, Xin XY. Exvivo experiments of human ovarian cancer ascites-derived exosomes presented by dendritic cells derived from umbilical cord blood for immunotherapy treatment. Clin Med Oncol. 2008;2:461-467.
- 112. Kobayashi M, Salomon C, Tapia J, Illanes SE, Mitchell MD, Rice GE. Ovarian cancer cell invasiveness is associated with discordant exosomal sequestration of Let-7 miRNA and miR-200. J Transl Med. 2014;12:4.

- Wyciszkiewicz A, Kalinowska-Łyszczarz A, Nowakowski B, Kaźmierczak K, Osztynowicz K, Michalak S. Expression of small heat shock proteins in exosomes from patients with gynecologic cancers. Sci Rep. 2019;9(1):9817.
- Liang B, Peng P, Chen S, et al. Characterization and proteomic analysis of ovarian cancer-derived exosomes. J Proteomics. 2013;80:171-182.
- 115. Yin J, Yan X, Yao X, et al. Secretion of annexin A3 from ovarian cancer cells and its association with platinum resistance in ovarian cancer patients. J Cell Mol Med. 2012;16(2):337-348.
- 116. Liang T, Guo Q, Li L, Cheng Y, Ren C, Zhang G. MicroRNA-433 inhibits migration and invasion of ovarian cancer cells via targeting Notch1. Neoplasma. 2016;63(5):696-704.
- 117. Wurz K, Garcia RL, Goff BA, Mitchell PS, Lee JH, Tewari M, Swisher EM. MiR-221 and MiR-222 alterations in sporadic ovarian carcinoma: relationship to CDKN1B, CDKNIC and overall survival. Genes Chromosomes Cancer. 2010;49(7):577-584.
- Huh JH, Kim TH, Kim K, et al. Dysregulation of miR-106a and miR-591 confers paclitaxel resistance to ovarian cancer. Br J Cancer. 2013;109(2):452-461.
- Sorrentino A, Liu CG, Addario A, Peschle C, Scambia G, Ferlini C. Role of microRNAs in drug-resistant ovarian cancer cells. Gynecol Oncol. 2008;111(3):478-486.
- Azmi AS, Bao B, Sarkar FH. Exosomes in cancer development, metastasis, and drug resistance: a comprehensive review. Cancer Metastasis Rev. 2013;32(3-4):623-642.
- Taylor DD, Gercel-Taylor C. MicroRNA signatures of tumor-derived exosomes as diagnostic biomarkers of ovarian cancer. Gynecol Oncol. 2008;110(1):13-21.
- 122. Li SD, Zhang JR, Wang YQ, Wan XP. The role of microRNAs in ovarian cancer initiation and progression. J Cell Mol Med. 2010;14(9):2240-2249.
- 123. Cappellesso R, Tinazzi A, Giurici T, et al. Programmed cell death 4 and microRNA 21 inverse expression is maintained in cells and exosomes from ovarian serous carcinoma effusions. Cancer Cytopathol. 2014;122(9):685-693.
- Vaksman O, Tropé C, Davidson B, Reich R. Exosome-derived miRNAs and ovarian carcinoma progression. Carcinogenesis. 2014;35(9):2113-2120.
- 125. Mahmoud EH, Fawzy A, A Elshimy RA. Serum MicroRNA-21 negatively relates to expression of programmed cell death-4 in patients with epithelial ovarian cancer. Asian Pac J Cancer Prev. 2018;19(1):33-38.
- Kinose Y, Sawada K, Nakamura K, Kimura T. The role of microRNAs in ovarian cancer. Biomed Res Int. 2014;2014:249393.
- Rana S, Lemoine E, Granger JP, Karumanchi SA. Preeclampsia: pathophysiology, challenges, and perspectives. Circ Res. 2019;124(7):1094-1112.
- 128. Uzan J, Carbonnel M, Piconne O, Asmar R, Ayoubi JM. Preeclampsia: pathophysiology, diagnosis, and management. Vasc Health Risk Manag. 2011;7:467-474.
- Phipps E, Prasanna D, Brima W, Jim B. Preeclampsia: updates in pathogenesis, definitions, and guidelines. Clin J Am Soc Nephrol. 2016;11(6):1102-1113.
- Berzan E, Doyle R, Brown CM. Treatment of preeclampsia: current approach and future perspectives. Curr Hypertens Rep. 2014;16(9):473.
- Guibourdenche J, Leguy MC, Tsatsaris V. Biologie des marqueurs de la pré-éclampsie [Biology and markers of preeclampsia]. Ann Biol Clin (Paris). 2013;71:79-87.
- Pillay P, Moodley K, Moodley J, Mackraj I. Placenta-derived exosomes: potential biomarkers of preeclampsia. Int J Nanomedicine. 2017;12:8009-8023.

- Gilani SI, Weissgerber TL, Garovic VD, Jayachandran M. Preeclampsia and extracellular vesicles. Curr Hypertens Rep. 2016;18(9):68.
- Salomon C, Rice GE. Role of exosomes in placental homeostasis and pregnancy disorders. Prog Mol Biol Transl Sci. 2017;145:163-179.
- Knight M, Redman CW, Linton EA, Sargent IL. Shedding of syncytiotrophoblast microvilli into the maternal circulation in preeclamptic pregnancies. Br J Obstet Gynaecol. 1998;105(6):632-640.
- 136. Redman CW, Sargent IL. Placental debris, oxidative stress and pre-eclampsia. Placenta. 2000;21(7):597-602.
- 137. Record M. Intercellular communication by exosomes in placenta: a possible role in cell fusion? Placenta. 2014;35(5):297-302.
- 138. Vargas A, Zhou S, Éthier-Chiasson M, et al. Syncytin proteins incorporated in placenta exosomes are important for cell uptake and show variation in abundance in serum exosomes from patients with preeclampsia. FASEB J. 2014;28(8):3703-3719.
- Pillay P, Maharaj N, Moodley J, Mackraj I. Placental exosomes and pre-eclampsia: maternal circulating levels in normal pregnancies and, early and late onset pre-eclamptic pregnancies. Placenta. 2016;46:18-25.
- Cronqvist T, Saljé K, Familari M, et al. Syncytiotrophoblast vesicles show altered micro-RNA and haemoglobin content after ex-vivo perfusion of placentas with haemoglobin to mimic preeclampsia. PLoS One. 2014;9(2):e90020.
- 141. Sandrim VC, Luizon MR, Palei AC, Tanus-Santos JE, Cavalli RC. Circulating microRNA expression profiles in preeclampsia: evidence of increased miR-885-5p levels. BJOG. 2016;123(13):2120-2128.
- 142. Ospina-Prieto S, Chaiwangyen W, Herrmann J, et al. MicroRNA-141 is upregulated in preeclamptic placentae and regulates trophoblast invasion and intercellular communication. Transl Res. 2016;172:61-72.
- 143. Truong G, Guanzon D, Kinhal V, et al. Oxygen tension regulates the miRNA profile and bioactivity of exosomes released from extravillous trophoblast cells - Liquid biopsies for monitoring complications of pregnancy. PLoS One. 2017;12(3):e0174514.
- 144. Felker J, Agnihotri S. Hurdling over the blood-brain barrier with exosome technology. Neuro Oncol. 2022;24(11):1884-1885.
- 145. Ma Y, Ma QW, Sun Y, Chen XF. The emerging role of extracellular vesicles in the testis. Hum Reprod. 2023;38(3):334-351.
- 146. Kenigsberg S, Wyse BA, Librach CL, da Silveira JC. Protocol for exosome isolation from small volume of ovarian follicular fluid: evaluation of ultracentrifugation and commercial kits. Methods Mol Biol. 2017;1660:321-341.
- 147. Mousaei Ghasroldasht M, Liakath Ali F, Park HS, et al. A comparative analysis of na.ve exosomes and enhanced exosomes with a focus on the treatment potential in ovarian disorders. J Pers Med. 2024;14(5):482.
- 148. Chen LY, Kao TW, Chen CC, et al. Frontier review of the molecular mechanisms and current approaches of stem cell-derived exosomes. Cells. 2023;12(7):1018.
- 149. Konala VB, Mamidi MK, Bhonde R, Das AK, Pochampally R, Pal R. The current landscape of the mesenchymal stromal cell secretome: a new paradigm for cell-free regeneration. Cytotherapy. 2016;18(1):13-24.
- Lu M, Peng L, Ming X, Wang X, et al. Enhanced wound healing promotion by immune response-free monkey autologous iPSCs and exosomes vs. their allogeneic counterparts. EBioMedicine. 2019;42:443-457.