Name: Nnamah Onyinye

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Question:

Factors that facilitate the movement of sperm in the female reproductive tract

Transport

- **Vaginal insemination**
  The complex process of sperm transport through the female reproductive tract begins at the time of ejaculation. During coitus, 1.5- to 5.0-ml of semen containing between 200 and 500 million sperm is deposited at the posterior vaginal fornix, leaving the external cervical os partially submerged in this pool of fluid. At this time, some sperm may be passively taken up by the cervix in a process described as "rapid transport;" otherwise, sperm undergo "delayed transport."
  The optimal pH for sperm viability is between 7.0 and 8.5, and a reduction in sperm motility is seen at a pH less than 6.0. Normal vaginal pH is only 3.5 to 4.0, and the acidic environment of the vagina is thus toxic to sperm. However, both seminal fluid and cervical mucus present within the posterior vagina are alkaline and act as buffers. Vaginal pH rises to 7.0 within just seconds after ejaculation, and this decrease in acidity can be maintained for up to two hours after ejaculation.

  Within about 1 minute after coitus, the ejaculate undergoes **coagulation**. This coagulum temporarily restricts movement of sperm out of the seminal clot, thus preventing their passage into the cervical mucus and ascension up the female reproductive tract. Over the next 20 to 30 minutes, however, a seminal-fluid proteolytic enzyme produced by the prostate gland gradually liquefies the clot. At this time, motile sperm may then enter the cervical mucus, leaving behind the seminal plasma. Although there are reports of motile sperm persisting within the vagina for up to 12 hours after ejaculation, motility of most vaginal sperm is diminished within about 30 minutes, and after 2 hours almost all sperm motility in the vagina has been lost.

- **Rapid Sperm Transport**

  Sperm may begin to undergo the process of rapid sperm transport within seconds after ejaculation. This type of sperm movement is thought to be **predominantly passive**, resulting from coordinated vaginal, cervical, and uterine contractions. Although these contractions are of short duration, they are believed to be the primary force responsible for the rapid progression of sperm to the upper female reproductive tract the **oviduct**.

- **The Cervix**

  Some important functions of the cervix:

  1. Providing a receptive environment for sperm entry near the time of ovulation
  2. Preventing access of sperm, microorganisms, and particulate matter to the upper reproductive tract and thus, the peritoneal cavity
  3. Filtering spermatozoa and removal of seminal plasma
  4. Preventing sperm phagocytosis by white blood cells within the female reproductive tract
  5. Providing a biochemical environment sufficient for sperm storage, capacitation, and migration

  The structure of the human cervix facilitates performance of these stated functions. The most important function of the cervix is producing mucus. Finally, cervical pH is alkaline, with a peak pH during the periovulatory period. This environment is much more hospitable to spermatozoa than the acidic pH of the vagina.

- **Cervical Mucus**

  Cervical mucus is continuously secreted through exocytosis by the non-ciliated epithelial cells that line the cervical canal. This biomaterial serves many important functions, including exclusion of seminal plasma, exclusion of morphologically abnormal sperm, and support of viable sperm for subsequent migration to the uterus and oviduct.

  It is a heterogeneous fluid with both high- and low-viscosity components. The amount of mucus produced and its composition and characteristics fluctuate with circulating progesterone and estrogen levels. As estrogen levels peak at mid cycle, cervical mucus is abundant in volume and thin in consistency because of increased water content. Under the influence of progesterone, water content decreases, and the mucus has a much higher viscosity.

  Ultra structurally, cervical mucus can be seen as a complex biphasic fluid with high viscosity and low viscosity components. The high viscosity gel phase is composed of a network of filamentous glycoproteins called *mucin.* Sperm movement through the cervical mucus is primarily through the interstitial spaces between the mucin micelles, and the sperm's progression depends on the size of these spaces.

  The size of the interstices is usually smaller than the size of the sperm heads; thus, sperm must push their way through the mucus as they proceed through the lower female genital tract.

  Spermatozoa may retain their fertilizing capacity in human cervical mucus for up to 48 hours and their motility for as long as 120 hours. From their temporary storage location within the cervical crypts, sperm can be released gradually over time, thus enhancing the probability of fertilization.

  Another potentially important feature of human cervical mucus is the belief that it is able to restrict migration of human spermatozoa with abnormal morphology. The percentage of spermatozoa with normal morphology in the cervical mucus and in the uterine fluid is significantly higher than usually seen in semen. The study of human sperm motility and morphology *in vitro* and they found that sperm with normal morphology swim faster than sperm with abnormal morphology, despite similar flagella frequencies and amplitudes. These results suggest that morphologically abnormal spermatozoa may experience decreased movement resulting from increased resistance of mucus.

- **Sperm Transport Through the Uterus**

  Little is known about sperm transport within the endometrial cavity. Sperm motility does not appear to be the only force directing the sperm toward the oviducts, because inert particles deposited within the uterus are transported to the Fallopian tubes. Uterine muscular contractions likely play a role in this process. Unfortunately, much difficulty has been met in attempts to recover and quantify uterine sperm.

  Quantitatively, the number of macrospheres progresses dramatically as the **follicular phase** progressed, with only a few particles entering the uterine cavity during the early follicular phase of the menstrual cycle. By the mid follicular phase, the proportion of macrospheres entering the uterine cavity increased dramatically, and by the late follicular phase, the highest level of macrosphere transported to the oviducts was noted.

  Other investigators have shown that near the time of ovulation, the number of spermatozoa is higher in the oviduct ipsilateral to the dominant follicle than in the contralateral oviduct on the side of the non-dominant follicle. The results of the above study, however, seem to suggest that lateralizing muscular contractile forces may play a significant role in this preferential movement, in that inert particles are obviously unable to engage in chemotactic migration.

- **Fallopian Tube**

  Sperm movement through the Fallopian tube relies on a combination of forces: intrinsic sperm motility, tubular muscular contraction, and fluid flow. Tubal fluid production is maximal at the time of ovulation, and this fluid sustains the sperm before fertilization. Tubal fluid may also facilitate both sperm capacitation and acrosomal reaction.

  Although the uterotubal junction does not act as a barrier to inert particles, it may serve as an additional functional barrier to sperm with abnormal morphology or motility. The number of sperm that reach the oviduct is many orders of magnitude lower than the total number of sperm in the ejaculate. Anatomic studies have shown that typically only hundreds of sperm are present in the oviduct at various postcoital timepoints into ampullary, isthmic, and intramural regions.