

Hyaluronan Expression on Vitrified Oocytes Before and After In Vitro Maturation

(EKSPRESI HYALURONAN PADA OOSIT YANG DIVITRIFIKASI
SEBELUM DAN SESUDAH MATURASI IN VITRO)

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ABSTRACT

Oocyte vitrification is a major challenge in assisted reproductive technology. Oocyte vitrification with cumulus cells provide benefits in the process of maturation and fertilization. Vitrification leads to rapid temperature changes, therefore the decreasing in temperature could damage the cells even when the morphology was normal. Vitrification of mature oocytes is common because of its low sensitiveness towards low temperatures than immature oocytes. The aim of the research was to compare the effect of vitrification before and after *in vitro* maturation to the expression of hyaluronan. Maturation was operated in medium TC 50 µL in CO₂ incubators for 24 hours. Vitrification started with washing oocyte in PBS basic medium supplemented with 20% serum for 1-2 minutes, then in equilibration medium PBS + 20% serum + 10% ethylene glycol for 10-14 minutes, then transferred to 20% serum + PBS + 0.5 M sucrose + 15% ethylene glycol + PROH 15% for 25-30 seconds. Thawing was processed by submerging the oocytes in the media: 1). PBS + 20% serum + 0.5 M sucrose (K1); 2) PBS + 20% serum + 0.25 M sucrose (K2); and 3). PBS + 20% serum + 0.1 M sucrose (K3). Immunocytochemical stain was performed to evaluate the hyaluronan expression. Remmele scale index (Immunoreactive score, IRS) was used to read the result. There was no differences of hyaluronan expression in oocyte and cumulus group of K1, K2 and K3 at p<0.05, statistically. We concluded that there was no difference of hyaluronan expression on oocyte and cumulus between vitrified oocyte of pre and post *in vitro* maturation which indicated that oocyte could be vitrified in the immature and mature state.

Keywords: vitrification; *in vitro* maturation; hyaluronan expression

ABSTRAK

Vitrifikasi oosit merupakan tantangan yang besar dalam teknologi reproduksi berbantu. Vitrifikasi oosit dengan sel kumulusnya memberikan keuntungan pada proses maturasi dan fertilisasi. Penelitian ini bertujuan membandingkan pengaruh vitrifikasi oosit sebelum dan sesudah maturasi *in vitro* terhadap ekspresi hyaluronan pada oosit dan sel kumulus. Oosit diaspirasi dari folikel berukuran 3-5 mm. Maturasi dilakukan dalam medium TCM 50 µl dalam inkubator CO₂ selama 24 jam. Vitrifikasi diawali dengan pencucian oosit dalam medium PBS yang disuplementasi serum 20% selama 1-2 menit, dilanjutkan dalam medium PBS + serum 20% + etilen glikol 10% selama 10-14 menit. Oosit kemudian dipindahkan dalam medium vitrifikasi PBS + serum 20% + sukrosa 0,5M + etilen glikol 15% + PROH 15% selama 25-30 detik. Thawing dilakukan dengan cara oosit direndam secara berturut dalam media : 1). PBS + 20% serum + sukrosa 0,5M, 2). PBS + 20% serum + sukrosa 0,25M, dan 3). PBS + 20% serum + sukrosa 0,1M. Dilakukan pemeriksaan imunositokimia untuk melihat ekspresi hyaluronan. Hasil pewarnaan dibaca dengan Indeks skala remmele (IRS). Ekspresi hyaluronan pada oosit dan kumulus K1, K2 da K0 tidak berbeda bermakna pada p<0,05 Tidak ada perbedaan ekspresi hyaluronan pada oosit dan sel kumulus antara kelompok kontrol dan perlakuan, hal ini menunjukkan oosit dapat divitrifikasi dalam keadaan matur dan immatur.

Kata-kata kunci: vitrifikasi; maturasi *in vitro*; ekspresi hyaluronan

INTRODUCTION

Vitrification of oocytes has become a promising technology and has evolved in assisted reproductive technology as it could prevent the formation ice crystals. The use of high concentrations of cryoprotectants and extremely rapid cooling will result in a change of shape from liquid to solid without the formation of ice crystals (Chang, 2008). The development of frozen oocyte stores was longer due to the typical physical properties of the oocyte. First, human oocytes have a typical critical size where the volume and surface ratios are low, causing limited penetration of water and cryoprotectants to penetrate the plasma membrane, then it will be difficult to protect the oocytes from the formation of intracellular ice crystals (Cotichio, 2004). Second, the mature oocyte contains spindle yarns that were particularly susceptible to a decrease in temperature (Chen, 2003).

Vitrification of mature oocytes was more commonly performed because it was more resistant to a decrease of temperature than immature oocytes (Otoi *et al.*, 1995). Vitrification was expected to give the same results both on immature and mature oocytes in order to give hope for storing oocytes in immature state.

Vitrification leads to very rapid temperature changes, if there was a decrease in temperature it will cause damage in the cell, although there was no morphological changes. Complex cutaneous oocytes that have been vitrified in mature and immature states show improved survival, cell division ability, and lower blastocyst ability compared to non vitrified oocytes (Zhou *et al.*, 2010). Cumulus cells have the ability to support oocyte maturation during the maturation process (Yuan *et al.*, 2005). In vitro maturation of oocytes immature that have been removed from cumulus cells indicates a mismatch of nucleus and cytoplasm maturity (Combelles *et al.*, 2002). The function of cumulus cells in mature oocytes was to increase sperm penetration and improve fertilization rates in conventional IVF (Tanghe *et al.*, 2003).

Granulosa cell damage especially in the immature oocytes would disrupt hyaluronan synthesis that the oocyte needs to achieve its maturation. Hyaluronan synthesis performed by complex cumulus oocytes was influenced by FSH and paracrine signals from oocytes (Spicer and McDonald, 1998).

Research on the effect of vitrification on hyaluronan expressions that affect oocyte

maturation has not been widely done at this time. This study aims was to study the hyaluronan expression in cumulus cells and cytoplasm of oocytes that were vitrified before and after in vitro maturation.

RESEARCH METHODS

The sheep oocytes samples were used in this study, collected from 3-5 mm follicles. The comparative experimental laboratory study with post test only control group design was used in this study. The oocyte was divided into three groups. IVM was performed in the control group. Group 1 was going through in vitro maturation before it was vitrified meanwhile; Group 2 was vitrified before going through in vitro maturation. In vitro maturation was performed in 38°C incubators, 5% CO₂ with 95% humidity for 24 hours. Vitrification was initiated by the washing of oocytes in a PBS-supplemented basal medium for up to 1-2 minutes, followed by equilibration of the oocyte in PBS + serum 20% + ethylene glycol 10% for 10-14 minutes. The oocyte was then transferred in vitrified medium of PBS + serum 20% + sucrose 0.5 m + ethylene glycol 15% + PROH 15% for 25-30 seconds. Thawing is done by dipping the hemistraw into thawing media. Oocytes were soaked sequentially into media consisting of: 1). PBS + 20% serum + sucrose 0.5M, 2).PBS + 20% serum + sucrose 0.25M, and 3).PBS + 20% serum + sucrose 0.1M. Immunocytochemical stain was performed by washing the preparations with PBS for 2x5 minutes, then protolithic digestion was performed with trypsin 0.025% in incubator with temperature of 37°C for 15 minutes, followed by H₂O₂ for 10 minutes, given the primary antibody for 60 minutes, the next step was biotinylated link for 30 minutes, followed by giving streptavidin for 30 minutes, then given diaminobenzidine (DAB) chromagen 2% diluted with DAB plus substrate for 6-10 minutes. Washing was performed by PBS for 2x5 minute each change of the phase in order to clean up the remaining substance. Counterstain was done with methyl green 3 for 5-10 minutes at room temperature then it was examined under light microscope. The coloring result was read by Remmele scale index (IRS) which was the result of multiplication between immunoreactive cell percentage score and color intensity score on the immunoreactive cells. Data analysis was done by using one-way analysis of variance.

RESULTS AND DISCUSSION

Immunocytochemical examination was used to find out hyaluronan expression in oocytes and cumulus cells. The positive expression was characterized by brownish color on oocytes and granulosa cells. Hyaluronan expression in oocytes and cumulus cells is summarized in Table 1.

Table 1 showed no significant difference in hyaluronan expression in oocyte and cumulus between control group and treatment group with $p < 0,05$.

Oocytes and cumulus cells need each other in their developmental processes, cumulus cells have a major role in vitro maturation and oocyte development (Shirazi *et al.*, 2007), at least three compact cumulus cell layers were required to protect oocytes and in vitro maturation (Ebrahimi *et al.*, 2010). While the oocyte secretes factors that could protect the cumulus from apoptosis by maintaining the localization of gradient anti apoptotic factors in complex cumulus oocytes (Hussein *et al.*, 2005; Hussein *et al.*, 2006). Knowledge of Oocyte-Secreted Factors (OSFs) which regulate the function of granulosa and cumulus complex to this day is still growing, which has been widely known is the Growth Differentiation Factors 9 (GDF9) and Bone Morphogenetic Protein 15 (BMP15) (McNatty *et al.*, 2004). GDF 9 increases the expression of Hyaluronic Acid Synthetase (HAS2), Cyclooxygenase 2 and Gremlin (Pangas *et al.*, 2004). Hyaluronan (HA) is an important component of expanding cumulus complex oocytes, hyaluronan synthesized in cell membranes by HA synthases (HAS) (Weigel *et al.*, 2007).

In this study, hyaluronan expression was higher in oocytes and cumulus cells in both treatment groups with no significant differences. In the vitrified group prior to in vitro maturation, hyaluronan expression was higher than in the vitrified group after in vitro maturation, although not significantly different. It seems that

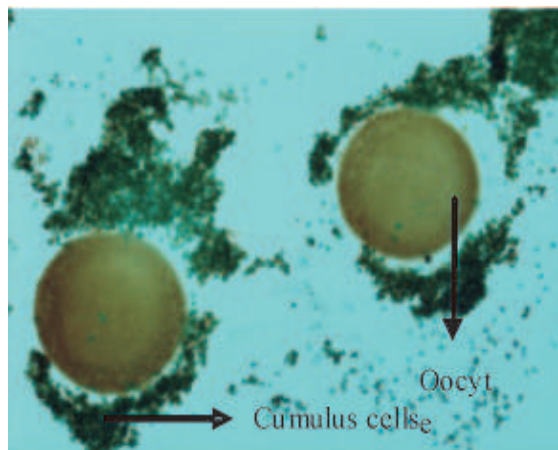


Figure 1. Hyaluronan expressions with immunocytochemical examination, cumulus cells and oocyte showed a score of 8(IRS)

the vitrification process does not affect in vitro maturation process.

The vitrification of the immature oocyte with its complex cumulus results in the death of the cumulus cells at the edges only, not on the inner part that close to the oocyte. Actin cytoskeleton on the surviving cumulus is also still well organized, as well as the gap junction between cumulus cells. Oocytes with complex cumulus images that experience death at multiple levels could still reach maturation (Tharasanit *et al.*, 2009). Oocytes protect the cumulus during culture, apoptotic COCs cultures occur in the outermost layer of the cumulus, whereas complex cumulus cultures with apoptotic oocyte cultures are found in the deepest cumulus layer (Hussein *et al.*, 2005). This was in accordance with the results of research that hyaluronan remains expressed in oocytes and cumulus was vitrified in the immature state that shows communication between oocyte and cumulus cell keep running, so that maturation could still be achieved.

Communication between cumulus cells and oocytes was instrumental in the process of oocyte maturation. The results of this study indicate

Table 1. Hyaluronan expression in oocytes and cumulus cells

Group	oocytes ± SD	cumulus ± SD
IVM (K0)	5,31 ± 1,62	3,01 ± 1,34
IVM+Vitrification (K1)	6,68 ± 2,80	5,75 ± 3,35
Vitrification+IVM (K2)	7,33 ± 4,75	6,67 ± 4,60

* = significant; IVM= in vitro maturation

that vitrification did not affect the oocyte maturation process, as the results obtained by Faizah *et al* (2014). That there was no difference in maturation of the vitrified oocytes before and after in vitro maturation.

This study used PROH as cryoprotectant, oosit viability after vitrification showed better results by using PROH, as well as embryonic development until blastocyst stage (Chian *et al.*, 2004).

Hyaluronan has the potential to improve the viability of embryos produced in vitro. Hyaluronan plays an important role in some cell functions including cell proliferation, cell migration, cell adhesion and cell signalling (Toole, 2001). The addition of hyaluronan to embryonic cattle culture could improve the development of embryos to the blastocyst stage (Jang *et al.*, 2003) and could improve the return of embryo expansion after vitrification (Block *et al.*, 2009) which has been shown in this study. The cumulus cells of Group K2 showed the highest hyaluronan expression compared to the other groups, so the oocytes also showed the highest hyaluronan expression compared to the other groups although not significantly different.

As the cumulus cell expands, cumulus cells secrete hyaluronan accumulated between cumulus cells. There were three types of genes in mammals encoding hyaluronan namely, Has 1, Has 2, Has 3 (Kimura *et al.*, 2002), but Has 1 was not detected in complex cytoplasm oocytes in cattle. In the culture for 12 hours and 24 hours, Has 2 was synthesized more than Has 3. The synthesis of Has 2 and Has 3 could be seen in the cross-sectional histologic images of complex cumulus oocytes that form composite and multilayered images of cumulus forming a sheath surrounding the oocyte. At the time of in vitro maturation, all cumulus cells attach strongly to one another, most of the cumulus cells scattered around the oocyte but still in the hyaluronan massive sheath. Only a layer of corona cells was still attached to the oocyte (Schoenfelder and Einspanier, 2003).

CONCLUSION

Based on this research, it was found that there was no difference of hyaluronan expression in oocytes and cumulus cells that were vitrified before and after in vitro maturation.

SUGGESTION

This study suggests that oocytes might be vitrified in immature and mature states.

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