Exosomes in developmental signalling

ABSTRACT

In order to achieve coordinated growth and patterning during development, cells must communicate with one another, sending and receiving signals that regulate their activities. Such developmental signals can be soluble, bound to the extracellular matrix, or tethered to the surface of adjacent cells. Cells can also signal by releasing exosomes – extracellular vesicles containing bioactive molecules such as RNA, DNA and enzymes. Recent work has suggested that exosomes can also carry signalling proteins, including ligands of the Notch receptor and secreted proteins of the Hedgehog and WNT families. Here, we describe the various types of exosomes and their biogenesis. We then survey the experimental strategies used so far to interfere with exosome formation and critically assess the role of exosomes in developmental signalling.

Introduction

M c f e ce - -ce c ca a cc d de e e ed a ed b c a c a d- ece e ac . I a ca e , e a d a ec e ed e . E a e c de e be f e WNT, Hed e (HH) a d b e e e c e (BMP) fa e . L a d ca a be a e b a e e , a e ca e f N c a d . A ec e ed a d ca eac a e ce b d ff , e e a ea a a e ace a e c e (EV) a c b e e e ea e a d ead f e e ca ca a d a d/ ed a e e a fe f a a e f b ca ac e ec e f e ce a e . S c e c e , ac a ed e , c e c ac d a d d , a e deed f d a e ace a e e . T e a e be ee 30 a d 1000 d a e e , a d a e c a f ed acc d e , ca e e a d f c (G d a d Ra , 2013). F e a e, EV f ed b e a d b dd f e a a e b a e a e a c e c e ec e (B 1), e ea EV a f e e d a e a e e ed e e (C c cc a d Me d e , 2015). He e, e f c e e a d e f a a d f c de e e .

ed a f e e ec e ; e e, e e a ce f e e e a ed a a a , e e ba e a e e c effec . A e e a ee c b e e e f c e Rab-GAP, TBC1D10 (H e a ., 2010). T e a e e GTPa e ac f RAB27 (I a d F da, 2006), ce a a RAB27 e e ec e . TBC1D10 add a ac a e RAB35, c a a bee c b e e e ec e (H e a ., 2010). Ye a e Rab fa e be ca ed e e d c RAB11 (Bec e e a ., 2013; K e e a ., 2012; Sa a e a ., 2002). I a , e e f a e d d a Rab fa e be ff c e c e e b c e e ec e , e a beca e f ed da c . A e a e , b e a eac f e e Rab c d e e ec e f a be f e e .

SNARE e ed a e e f f e c e e a e e b a e c a e a d a e e ef e e c b e e e ea e f ILV a e e . Ve c e SNARES (SNARE) ca ed e MVB ec e a e SNARES (SNARE) ca ed a e a a e b a e d e f f e e b a e (Ca e a ., 2007). T e e ac ac e e ed f MVB a a e b a e f a bee f e c da ed. T e SNARE e VAMP7 a bee e ed ed a e e e ec e , a a bee d ed (Fade e a ., 2009; P -G a dea e a ., 2007). T e Drosophila SNARE YKT6 a d S a 1A a e bee e ed e a e e e-ed a ed ec e f W e (G e a ., 2012; K e e a ., 2012). H e e , e d ff c e a a e beca e e e SNARE e c b e f a a e e ec e a d e d c c a a (Ja a d Sc e e , 2006). T e a fa SNARE e be ec f ca ed e e e ea e.

The role of exosomes in developmental signalling

G e e a ed ca e , a d e e e a fe f b ec e (ee B 1), e e a e bee e a ed a e a ed a f a d de e e , a c a e c e f WNT a d HH a . T e WNT a d HH a a a e a e a d a e d e b c de e e (Pe , 1994; Pe e a ., 2012; a A e e a d N e, 2009), a e a e ce be e e a c a e f e a d e (C e e e a ., 2014). U e e ace a a e , HH a d WNT a e d f ed b e add f a d d e b e . T a e e e beca e e d e affec e aff c , b a d d ff f e e a e e e ace a ace. T e e e e f -a e a b WNT a d HH a bee e b ec f deba e (A e a d e e a ., 2014; Fa e a ., 2016; Se a b a d Ma ce e, 2014). Ne e e e , b e a e bee ac e e e a ce d a e e (N e , 2010; Pe e a ., 2012; S a d C e , 1997; Zecca e a ., 1996). H d- d f ed, a d e ce b e, e ca ac e e -a e ac a a e ce a d de e e a b . O e b a WNT a d HH a eed d ff e de ac a a a e. I deed, a bee e ed a e e e c d e a e e ed ec a ed a f d a ca ed c e e , c e e d d a ce (B c ff e a ., 2013; H e a ., 2005; Ra e -Webe a d K be , 1999; S a e a d Sc , 2016). H e e , e e a e ec f c ea f e e c e e f a , ec d a d ec e f de . O e a e a e c e e a e a ce , c a e ed d a e c c a , ac a e c e f WNT a d HH . S ec f ca , e d add c d e e a ce' e d a e a d e d c e (Pa a a e a ., 2005). A e de a e d add c f WNT HH c d be e ded b a e ace a d b d c a e e , c a SWIM (Sec e ed W e I e ac M ec e), a e be f e ca fa (M a e a ., 2012). Ye a e b , e ed f HH, a e d add c c d be e ded de ce e (G e e a ., 2006; Ze e a ., 2001), a de a

a e ac e d b. a d ac f W e (Bec e
e a ., 2013). T ed e a. f 7.4(ed)

Complex targeted	RNAi or DN used*	References	Effect	Caveats/other effects
Small GTPase	RAB11	Koles et al., 2012	Reduced release of WLS-containing vesicles from S2 cells; reduced postsynaptic WLS at neuromuscular junction	RAB11 regulates endocytic recycling; regulates membrane delivery during cytokinesis; participates in epithelial cell polarisation; regulates transcytosis of certain cargo; may be redundant with other Rabs
		Beckett et al., 2013	Reduced exosome release by S2 cells; no effect on Wingless gradient in imaginal discs	
		Gross et al., 2012	Lethal	
		Gradilla et al., 2014	Reduced HH secretion and/or target gene expression imaginal disc	
	RAB35	Beckett et al., 2013	No effect on exosome release from S2 cells	RAB35 regulates endocytic recycling; regulates endosomal trafficking of synaptic vesicles; may be redundant with other Rabs

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