Developmental Biology

Volume 233, Issue 2, 15 May 2001, Pages 347-364

Regular Article

Study of the Murine Allantois by Allantoic Explants

Karen M Downs [1] … Jacalyn McHugh

Show more

https://doi.org/10.1006/dbio.2001.0227

Abstract

The murine allantois will become the umbilical artery and vein of the chorioallantoic placenta. In previous studies, growth and differentiation of the allantois had been elucidated in whole embryos. In this study, the extent to which explanted allantoises grow and differentiate outside of the conceptus was investigated. The explant model was then used to elucidate cell and growth factor requirements in allantoic development. Early headfold-stage murine allantoises were explanted directly onto tissue culture plastic or suspended in test tubes. Explanted allantoises vascularized with distal-to-proximal polarity, they exhibited many of the same signaling factors used by the vitelline and cardiovascular systems, and they contained at least three cell types whose identity, gene expression profiles, topographical associations, and behavior resembled those of intact allantoises. DiI labeling further revealed that isolated allantoises grew and vascularized in the absence of significant cell mingling, thereby supporting a model of mesodermal differentiation in the allantois that is position- and possibly age-dependent. Manipulation of allantoic explants by varying growth media demonstrated that the allantoic endothelial cell lineage, like that of other embryonic vasculatures, is responsive to $VEGF_{164}$. Although $VEGF_{164}$ was required for both survival and proliferation of allantoic angioblasts, it was not sufficient to induce appropriate epithelialization of these cells. Rather, other VEGF isoforms and/or the outer sheath of mesothelium, whose maintenance did not appear to be dependent upon endothelium, may also play important roles. On the basis of these findings, we propose murine allantoic explants as a new tool for shedding light not only on allantoic development, but for elucidating universal mechanisms of blood vessel formation, including vascular supporting cells, either in the intact organism or in existing *in vitro* systems.

Keywords

allantois; angioblasts; chorion; embryos; endothelium; *flk1*; *flt1*; immunohistochemistry; *in vitro*; *lacZ*; mesenchyme; mesothelium; mouse; placenta; smooth muscle; *tie1*; *tie2*; transplantation; vasculogenesis; *VCAM1*; *VEGF*

References

REFERENCES

1 B Barleon, S Sozzani, D Zhou, H.A Weich, A Mantovani, D Marme
Migration of human monocytes in response to vascular endothelial growth factor (VEGF) is mediated via the VE
Blood, 87 (1996), pp. 3336-3343

2 K Bonnevie
New facts on mesoderm formation and proamnion derivatives in the normal mouse embryo
J. Morphol., 86 (1950), pp. 495-546

3 N.A Brown
Routine assessment of morphology and growth: Scoring systems and measurements of size
A.J Copp, D.L Cockroft (Eds.), Postimplantation Mammalian Embryos: A Practical Approach, IRL Press, Oxford (1990)

4 J.J Brown, V.E Papaioannou
Ontogeny of hyaluronan secretion during early mouse development
Development, 117 (1993), pp. 483-492

5 Carmeliet
Abnormal blood vessel development and lethality in embryos lacking a single VEGF allele
Nature, 380 (1996), pp. 435-439

6 K.M Downs
The murine allantois
R Pedersen, G Schatten (Eds.), Current Topics in Developmental Biology, Academic Press, New York (1998), pp. 1-33
Article PDF (2MB)

7 K.M Downs, T Davies
Staging of gastrulation in mouse embryos by morphological landmarks in the dissection microscope
Development, 118 (1993), pp. 1255-1266

8 K.M Downs, R.L Gardner
An investigation into early placental ontogeny: Allantoic attachment to the chorion is selective and developmentally-regulated
Development, 121 (1995), pp. 407-416

9 K.M Downs, C Harmann
Developmental potency of the murine allantois
Development, 124 (1997), pp. 2769-2780

10 K.M Downs, S Gifford, M Blahnik, R.L Gardner
The murine allantois undergoes vasculogenesis that is not accompanied by erythropoiesis
Development, 125 (1998), pp. 4507-4521

11 K.M Downs, C Bertler
Growth in the pre-fusion murine allantois
Anat. Embryol., 202 (2000), pp. 323-331

12 C.J Drake, C.D Little
VEGF and vascular fusion: Implications for normal and pathological vessels
J. Histochem. Cytochem., 47 (1999), pp. 1351-1356

13 D.J Dumont, G.-H Fong, M.C Puri, G Gradwohl, K Alitalo, M.L Breitman
Vascularization of the embryo: A study of flk-1, tek, tie, and vascular endothelial growth factor expression during development
Dev. Dyn., 203 (1995), pp. 80-92

14 S.K.L Ellington
A morphological study of the development of the allantois of rat embryos in vivo
J. Anat., 142 (1985), pp. 1-11

15 S Esser, M.G Lamugnani, M Corada, E Dejana, W Risau
Vascular endothelial growth factor induces VE-cadherin tyrosine phosphorylation in endothelial cells
J. Cell Sci., 111 (1998), pp. 1853-1865

16 N Ferrara, H Heinsohn, C.E Walder, S Bunting, G.R Thomas
The regulation of blood vessel growth by vascular endothelial growth factor
Ann. N. Y. Acad. Sci., 752 (1995), pp. 246-256

17 N Ferrara, K Carver-Moore, H Chen, M Dowd, L Lu, K.S O'Shea, L Powell-Braxton, K.J Hillan, M.W Moore
Heterozygous embryonic lethality induced by targeted inactivation of the VEGF gene

Nature, 380 (1996), pp. 439-442

18 G.-H Fong, J Rossant, M Gertsenstein, M.L Breitman
Role of the Flt-1 receptor tyrosine kinase in regulating the assembly of vascular endothelium
Nature, 376 (1995), pp. 66-70

19 R.L Gardner, M.F Lyon, E.P Evans, M.D Burtenshaw
Clonal analysis of X-chromosome inactivation and the origin of the germ line in the mouse embryo
J. Embryol. Exp. Morphol., 88 (1985), pp. 349-363

20 R.L Gardner, D.L Cockcroft
Complete dissipation of coherent clonal growth occurs before gastrulation in mouse epiblast
Development, 125 (1998), pp. 2397-2402

21 A.C Gittenberger-deGroot, M.C DeRuiter, M Bergwerff, R.E Poelmann
Smooth muscle cell origin and its relation to heterogeneity in development and disease
Arterioscler. Thromb. Vasc. Biol., 19 (1999), pp. 1589-1594

22 G.C Gurtner, V Davis, H Li, M.J McCoy, A Sharpe, M.I Cybulsky
Targeted disruption of the murine VCAM1 gene: Essential role of VCAM-1 in chorioallantoic fusion and placentation
Genes Dev., 9 (1995), pp. 1-14

23 J Jolly, M Férester-Tadié
Recherches sur l'oeuf et de la souris
Arch. d'Anat. Microsc., 32 (1936), pp. 322-390

24 M.H Kaufman
The Atlas of Mouse Development, Academic Press, London (1992)

25 S.J Kinder, T.E Tsang, G.A Quinlan, A.K Hadjantonakis, A Nagy, P.P Tam
The orderly allocation of mesodermal cells to the extraembryonic structures and the anteroposterior axis during gastrulation of the mouse embryo
Development, 126 (1999), pp. 4691-4701

26 L Kwee, H.S Baldwin, H.M Shen, C.L Steward, C Buck, C.A Buck, M.A Labow
Defective development of the embryonic and extraembryonic circulatory systems in vascular cell adhesion molecule (VCAM-1) deficient mice
Development, 121 (1995), pp. 489-503

27 K.A Lawson, J.J Meneses, R.A Pedersen
Cell fate and cell lineage in the endoderm of the presomite mouse embryo, studied with an intracellular tracer
Dev. Biol., 115 (1986), pp. 325-339
Article PDF (5MB)

28 K.A Lawson, J Meneses, R.A Pedersen
Clonal analysis of epiblast fate during germ layer formation in the mouse embryo
Development, 113 (1991), pp. 891-911

29 K Miller
Immunocytochemical techniques
J.D Bancroft, A Stevens (Eds.), Theory and Practice of Histological Techniques, Churchill Livingstone, New York (1996), pp. 435-470

30 L Miquerol, M Gersenstein, K Harpal, J Rossant, A Nagy
Multiple developmental roles of VEGF suggested by a LacZ-tagged allele
Dev. Biol., 212 (1999), pp. 307-322
Article PDF (1MB)

31 V Nehls, D Drenckhahn
The versatility of microvascular pericytes: From mesenchyme to smooth muscle?
Histochemistry, 99 (1993), pp. 1-12

32 G Neufeld, T Cohen, S Gengrinovitch, Z Poltorak
Vascular endothelial growth factor (VEGF) and its receptors

FASEB J., 13 (1999), pp. 9-22

33 D.M Noden
Origins and assembly of avian embryonic blood vessels
Ann. N. Y. Acad. Sci., 1 (1990), pp. 236-249

34 G.K Owens
Regulation of differentiation of vascular smooth muscle cells
Physiol. Rev., 75 (1995), pp. 487-517

35 S Patan, B Haenni, P.H Burri
Evidence for intussusceptive capillary growth in the chicken chorioallantoic membrane (CAM)
Anat. Embryol., 187 (1993), pp. 121-130

36 W Risau, I Flamme
Vasculogenesis
Annu. Rev. Cell Dev. Biol., 11 (1995), pp. 73-91

37 T.N Sato, Y Tozawa, U Deutsch, K Wolburg-Buchhoz, Y Fujiwara, M Gendron-Maguire, T Gridley, H Wolburg, W Risau, Y Qin
Distinct roles of the receptor tyrosine kinases Tie-1 and Tie-2 in blood vessel formation
Nature, 376 (1995), pp. 70-74

38 T.M Schlaeger, Y Qin, Y Fujiwara, J Magram, T.N Sato
Vascular endothelial cell lineage-specific promoter in transgenic mice
Development, 121 (1995), pp. 1089-1098

39 F Shalaby, J Rossant, T.P Yamaguchi, M Gertsenstein, X-F Wu, M.L Breitman, A.C Schuh
Failure of blood-island formation and vasculogenesis in Flk-1 deficient mice
Nature, 376 (1995), pp. 62-66

40 G.D Snell, L.C Stevens
Early Embryology
E.L Green (Ed.), Biology of the Laboratory Mouse, McGraw–Hill, New York (1966), pp. 205-245

41 P.P.L Tam, R.S.P Beddington
The formation of mesodermal tissues in the mouse embryo during gastrulation and early organogenesis
Development, 99 (1987), pp. 109-126

42 J Waltenberger, L Claesson-Welch, A Siegbahn, M Shibuya, C.-H Heldin
Different signal transduction properties of KDR and Flt1, two receptors for vascular endothelial growth factor
J. Biol. Chem., 269 (1994), pp. 26988-26995

43 T.P Yamaguchi, D.J Dumont, R.A Conlon, M.L Breitman, J Rossant
flk-1, an flt-related receptor tyrosine kinase, is an early marker for endothelial cell precursors
Development, 118 (1993), pp. 488-489

44 J Yamashita, H Itoh, M Hirashima, M Ogawa, S Nishikawa, T Yurugi, M Naito, K Nakao, S.-I Nishikawa
Flk-1-positive cells derived from embryonic stem cells serve as vascular progenitors
Nature, 408 (2000), pp. 92-96

45 J.T Yang, H Rayburn, R.O Hynes
Cell adhesion events mediated by a4 integrins are essential in placental and cardiac development
Development, 121 (1995), pp. 549-560

46 I.-T Yeh, R.J Kurman
Functional and morphologic expressions of trophoblast
Lab. Invest., 61 (1989), pp. 1-4

47 A Yoshida, B Anand-Apte, B.R Zetter
Differential endothelial migration and proliferation to basic fibroblast growth factor and vascular endothelial growth factor
Growth Factors, 13 (1996), pp. 57-64

1 To whom correspondence should be addressed. Fax: (608) 262-7306. E-mail: kdowns@facstaff.wisc.edu.