Genová terapie v urologii: způsoby přenesení teorie do praxe

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LITERATURA

- 1 Rochester MA, Brewster SF. Genetics for urologists. *BJU Int* 2004; 94: 232–7
- 2 Walsh CE. Gene therapy progress and prospects: gene therapy for the hemophilias. *Gene Ther* 2003; **10**: 999– 1003
- 3 **Christ GJ.** Gene therapy treatments for erectile and bladder dysfunction. *Curr Urol Rep* 2004; **5**: 52–60
- 4 Miles BJ, Shalev M, Aguilar-Cordova E et al. Prostatespecific antigen response and systemic T cell activation after in situ gene therapy in prostate cancer patients failing radiotherapy. *Hum Gene Ther* 2001; 12: 1955–67
- 5 Krasnykh V, Dmitriev I, Mikheeva G, Miller CR, Belousova N, Curiel DT. Characterization of an adenovirus vector containing a heterologous peptide epitope in the HI loop of the fiber knob. J Virol 1998; 72: 1844–52
- 6 Gonzalez R, Vereecque R, Wickham TJ et al. Increased gene transfer in acute myeloid leukemic cells by an adenovirus vector containing a modified fiber protein. Gene Ther 1999; 6: 314–20
- 7 Nicklin SA, White SJ, Watkins SJ, Hawkins RE, Baker AH. Selective targeting of gene transfer to vascular endothelial cells by use of peptides isolated by phage display. *Circulation* 2000; 102: 231–7
- 8 Magnusson MK, Hong SS, Boulanger P, Lindholm L. Genetic retargeting of adenovirus: novel strategy

employing 'deknobbing' of the fiber. *J Virol* 2001; **75**: 7280–9

- 9 Krasnykh V, Belousova N, Korokhov N, Mikheeva G, Curiel DT. Genetic targeting of an adenovirus vector via replacement of the fiber protein with the phage T4 fibritin. J Virol 2001; 75: 4176–83
- 10 Douglas JT, Rogers BE, Rosenfeld ME, Michael SI, Feng M, Curiel DT. Targeted gene delivery by tropismmodified adenoviral vectors. *Nat Biotechnol* 1996; 14: 1574–8
- 11 Gu DL, Gonzalez AM, Printz MA *et al.* Fibroblast growth factor 2 retargeted adenovirus has redirected cellular tropism. evidence for reduced toxicity and enhanced antitumor activity in mice. *Cancer Res* 1999; **59**: 2608–14
- 12 Haisma HJ, Pinedo HM, Rijswijk A *et al.* Tumorspecific gene transfer via an adenoviral vector targeted to the pancarcinoma antigen EpCAM. *Gene Ther* 1999; 6: 1469–74
- 13 Tillman BW, de Gruijl TD, Luykx-de Bakker SA *et al.* Maturation of dendritic cells accompanies high-efficiency gene transfer by a CD40targeted adenoviral vector. *J Immunol* 1999; 162: 6378–83
- 14 Nakamura T, Sato K, Hamada H. Reduction of Natural adenovirus tropism to the liver by both ablation of fibercoxsackievirus and adenovirus receptor interaction and use of replaceable short fiber. J Virol 2003; 77: 2512– 21

- 15 Rubanyi GM. The future of human gene therapy. *Mol Aspects Med* 2001; 22: 113– 42
- 16 Miller AD. The problem with cationic liposome/micellebased non-viral vector systems for gene therapy. *Curr Med Chem* 2003; **10**: 1195–211
- 17 Zuber G, Zammut-Italiano L, Dauty E, Behr JP. Targeted gene delivery to cancer cells. directed assembly of nanometric DNA particles coated with folic acid. *Angew Chem Int Ed Engl* 2003; **42**: 2666–9
- 18 Connor RJ, Engler H, Machemer T *et al.* Identification of polyamides that enhance adenovirusmediated gene expression in the urothelium. *Gene Ther* 2001; **8**: 41–8
- 19 Kichler A. Gene transfer with modified polyethylenimines. J Gene Med 2004; 6 (Suppl. 1): S3–10
- 20 Fisher KD, Stallwood Y, Green NK, Ulbrich K, Mautner V, Seymour LW. Polymer-coated adenovirus permits efficient retargeting and evades neutralising antibodies. *Gene Ther* 2001; 8: 341–8
- Kraaij R, van Rijswijk AL, Oomen MH, Haisma HJ, Bangma CH. Specific Membrane Antigen (PSMA) is a tissuespecific target for adenoviral transduction of prostate cancer in vitro. *Prostate* 2005; 62: 253–9
 Bangma CH, Kraaij R,
 - 2 Bangma CH, Kraaij R, Oomen MHTh, Van Rijswijk AL, De Ridder CM. Adenoviral mediated gene therapy for

BJU INTERNATIONAL, Vol. 96, Number 8, December 2005, 1163-1170 European Urology Update Series 2005:6

prostate cancer. studies on vector tropism and payload. *Prostate Cancer Prostatic Dis* 2000; **3**: S5

- 23 Gong MC, Chang SS, Watt F et al. Overview of evolving strategies incorporating prostate-specific membrane antigen as target for therapy. *Mol Urol* 2000; 4: 217–22
- 24 Haviv YS, Blackwell JL, Kanerva A *et al.* Adenoviral gene therapy for renal cancer requires retargeting to alternative cellular receptors. *Cancer Res* 2002; **62** : 4273– 81
- 25 van der Poel HG, Molenaar B, van Beusechem VW et al. Epidermal growth factor receptor targeting of replication competent adenovirus enhances cytotoxicity in bladder cancer. J Urol 2002; 168: 266–72
- 26 Gotoh A, Ko SC, Shirakawa T *et al.* Development of prostate-specific antigen promoter-based gene therapy for androgen-independent human prostate cancer. *J Urol* 1998; **160**: 220–9
- 27 Cheng WS, Giandomenico V, Pastan I, Essand M. Characterization of the androgen-regulated prostatespecific T cell receptor gamma-chain alternate reading frame protein (TARP) promoter. *Endocrinology* 2003; 144: 3433–40
- 28 Schalken JA, Hessels D, Verhaegh G. New targets for therapy in prostate cancer: differential display code 3 (DD3 PCA3), a highly prostate cancer-specific gene. Urology 2003; 62: 34–43
- 29 Pramudji C, Shimura S, Ebara S et al. In situ prostate cancer gene therapy using a novel adenoviral vector regulated by the caveolin-1 promoter. *Clin Cancer Res* 2001; 7: 4272–9
- 30 Lee SJ, Kim HSYuR, Lee K *et al.* Novel prostate-specific promoter derived from PSA

and PSMA enhancers. *Mol Ther* 2002; **6**: 415–21

- 31 Bahrenberg G, Brauers A, Joost HG, Jakse G. Reduced expression of PSCA, a member of the LY-6 family of cell surface antigens, in bladder, esophagus, and stomach tumors. *Biochem Biophys Res Commun* 2000; 275: 783–8
- 32 Ganly I, Kirn D, Eckhardt G et al. A phase I study of Onyx-015, an E1B attenuated adenovirus, administered intratumorally to patients with recurrent head and neck cancer. *Clin Cancer Res* 2000; 6: 798–806
- 33 DeWeese TL, van der Poel H, Li S et al. A phase I trial of CV706, a replicationcompetent, PSA selective oncolytic adenovirus, for the treatment of locally recurrent prostate cancer following radiation therapy. *Cancer Res* 2001; 61: 7464– 72
- 34 Rodriguez R, Schuur ER, Lim HY, Henderson GA, Simons JW, Henderson DR. Prostate attenuated replication competent adenovirus (ARCA) CN706: a selective cytotoxic for prostate-specific antigenpositive prostate cancer cells. *Cancer Res* 1997; 57: 2559– 63
- 35 Kirn D, Martuza RL, Zwiebel J. Replication-selective virotherapy for cancer. biological principles, risk management and future directions. *Nat Med* 2001; 7: 781–7
- 36 Kraaij R, Oomen MHA, van Rijswijk ALCT, de Ridder CMA, van der Linden RMM, Bangma CH. Adenovirusmediated expression of PTEN in the PC-346C human prostate cancer model induces growth suppression (Abstract). Amer Soc Gene Ther 2001
- 37 Nicholas TW, Read SB, Burrows FJ, Kruse CA.

Suicide gene therapy with Herpes simplex virus thymidine kinase and ganciclovir is enhanced with connexins to improve gap junctions and bystander effects. *Histol Histopathol* 2003; **18**: 495–507

- 38 Freytag SO, Khil M, Stricker H et al. Phase I study of replication-competent adenovirus-mediated double suicide gene therapy for the treatment of locally recurrent prostate cancer. Cancer Res 2002; 62: 4968–76
- 39 Nasu Y, Bangma CH, Hull GW et al. Adenovirusmediated interleukin-12 gene therapy for prostate cancer. Suppression of orthotopic tumor growth and preestablished lung metastases in an orthotopic model. Gene Ther 1999; 6: 338–49
- 40 Hall SJ, Mutchnik SE, Chen SH, Woo SL, Thompson TC. Adenovirus-mediated herpes simplex virus thymidine kinase gene and ganciclovir therapy leads to systemic activity against spontaneous and induced metastasis in an orthotopic mouse model of prostate cancer. *Int J Cancer* 1997; **70**: 183–7
- 41 Reynolds PN, Nicklin SA, Kaliberova L et al. Combined transductional and transcriptional targeting improves the specificity of transgene expression in vivo. Nat Biotechnol 2001; 19: 838– 42
- 42 Douglas JT, Kim M, Sumerel LA, Carey DE, Curiel DT. Efficient oncolysis by a replicating adenovirus (ad) *in vivo* is critically dependent on tumor expression of primary ad receptors. *Cancer Res* 2001; 61: 813–7
- 43 Fechner H, Haack A, Wang H et al. Expression of coxsackie adenovirus receptor and alphav-integrin does not correlate with adenovector targeting *in vivo* indicating

BJU INTERNATIONAL, Vol. 96, Number 8, December 2005, 1163-1170 European Urology Update Series 2005:6

anatomical vector barriers. Gene Ther 1999; 6: 1520–35

- 44 Ebara S, Shimura S, Nasu Y et al. Gene therapy for prostate cancer. Toxicological profile of four HSV-tk transducing adenoviral vectors regulated by different promoters. *Prostate Cancer Prostatic Dis* 2002; 5: 316–25
- 45 Jongmans W, Tiemessen DM, Oosterwijk E, Mulders PE. Letter to: Adenoviral gene therapy for renal cancer requires retargeting to alternative cellular receptors. *Cancer Res* 2003; **63**: 1994–5
- Jongmans W, van den Oudenalder K, Tiemessen DM *et al.* Targeting of adenovirus to human renal cell carcinoma cells. *Urology* 2003; 62: 559–65
- 47 Moiseyenko VM, Danilov AO, Baldueva IA et al. Phase I/II trial of gene therapy with autologous tumor cells modified with tag7/PGRP-S gene in patients with disseminated solid tumors: miscellaneous tumors. Ann Oncol 2005; 16: 162–8
- 48 Koike H, Tomita N, Azuma H et al. An efficient gene transfer method mediated by ultrasound and microbubbles into the kidney. *Gene Med* 2005; 7: 108–16
- 49 Ardelt P, Bohle A. Molecular aspects of bladder cancer IV. gene therapy of bladder cancer. *Eur Urol* 2002; 41: 372–80
- 50 Dumey N, Mongiat-Artus P, Devauchelle P *et al.* In vivo retroviral mediated gene transfer into bladder urothelium results in preferential transduction of tumoral cells. *Eur Urol* 2005; **47**: 257–63
- 51 Ramesh N, Memarzadeh B, Ge Y, Frey D, VanRoey M, Rojas V, YuDC. Identification of pretreatment agents to enhance adenovirus infection

of bladder epithelium. *Mol Ther* 2004; **10**: 697–705

- 52 Yang Y, Nunes FA, Berencsi K, Furth EE, Gonczol E, Wilson JM. Cellular immunity to viral antigens limits E1deleted adenoviruses for gene therapy. *Proc Natl Acad Sci USA* 1994; **91**: 4407–11
- 53 Zhang J, Ramesh N, Chen Y et al. Identification of human uroplakin II promoter and its use in the construction of CG8840, a urothelium-specific adenovirus variant that eliminates established bladder tumors in combination with docetaxel. *Cancer Res* 2002; 62: 3743–50
- 54 Pagliaro LC, Keyhani A, Williams D et al. Repeated intravesical instillations of an adenoviral vector in patients with locally advanced bladder cancer: a phase I study of p53 gene therapy. J Clin Oncol, 2003; 21: 2247–53
- 55 Shalev M, Kadmon D, Teh BS *et al.* Suicide gene therapy toxicity after multiple and repeat injections in patients with localized prostate cancer. *J Urol* 2000; **163**: 1747–?1750
- 56 Herman JR, Adler HL, Aguilar-Cordova E et al. In situ gene therapy for adenocarcinoma of the prostate: a phase I clinical trial. Hum Gene Ther 1999; 10: 1239–49
- 57 Teh BS, Aguilar-Cordova E, Vlachaki MT *et al.* Combining radiotherapy with gene therapy (from the bench to the bedside): a novel treatment strategy for prostate cancer. *Oncologist* 2002; 7: 458–66
- 58 Kubo H, Gardner TA, Wada Y et al. Phase I dose escalation clinical trial of adenovirus vector carrying osteocalcin promoter-driven herpes simplex virus thymidine kinase in localized and metastatic hormone-refractory prostate

cancer. *Hum Gene Ther* 2003; 14: 227–41

- 59 Cheng WS, Kraaij R, Nilsson B et al. A novel TARPpromoter-based adenovirus against hormone-dependent and hormone-refractory prostate cancer. *Mol Ther* 2004; **10**: 355–64
- 60 Li X, Zhang YP, Kim HS *et al.* Gene therapy for prostate cancer by controlling adenovirus E1a and E4 gene expression with PSES enhancer. *Cancer Res* 2005; 65: 1941–51
- 61 Shen ZJ, Wang H, Lu YL, Zhou XL, Chen SW, Chen ZD. Gene transfer of vasoactive intestinal polypeptide into the penis improves erectile response in the diabetic rat. *BJU Int* 2005; 95: 890–4
- 62 Bivalacqua TJ, Deng W, Champion HC, Hellstrom WJ, Kadowitz PJ. Gene therapy techniques for the delivery of endothelial nitric oxide synthase to the corpora cavernosa for erectile dysfunction. *Meth Mol Biol* 2004; **279**: 173–85
- 63 Van Weerden WM, Romijn JC. Use of nude mouse xenograft models in prostate cancer research. *Prostate* 2000; **43**: 263–71

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Zkratky:

CAR, coxsackie adenoviral receptor; PSMA, prostate specific membrane antigen; PSCA, prostate specific stem-cell antigen; HSV-TK, herpes simplex virusthymidine kinase.