Técnica de liberación mejorada por convección CED

<html><iframe width="560" height="315" src="http://www.youtube.com/embed/uQgG_YvFS5o" frameborder="0" allowfullscreen></iframe></html>

La administración directa al tumor mediante la técnica de liberación mejorada por convección (CED), empleando catéteres insertados en el cerebro antes o después de una resección quirúrgica tumoral.

El objetivo se consigue con un gradiente de presión hidrostática a través de los espacios intersticiales del cerebro.

Se trata de una técnica junto a la administración intracavitaria de carmustina o reservorios subcutaneos para evitar la barrera hematoencefálica en la administración de quimioterápicos.

La administración de inmunotoxinas a los tumores cerebrales para eludir la barrera sanguínea del cerebro es un desafío importante.

La eficacia de la CED se determina a través de la distribución del agente terapéutico para la región objetivo. La gran mayoría de los pacientes no reciben una cantidad significativa de cobertura del área en riesgo de recurrencia tumoral (Mehta y col., 2011).

Una de las dificultades es conocer que localización y tejidos son los que se debe de evitar (ya que pueden estar asociados a la morbilidad quirúrgica), antes de planificar ensayos clínicos que utilizan la tecnología basada en la convección (Shahar y col., 2011).

Se han presentado problemas técnicos importantes, como el reflujo, que han contribuido a los decepcionantes resultados de dos ensayos clínicos de fase III que lo investigó con cintredekin besudotox y TransMid ™ en pacientes con glioblastoma recurrente (Buonerba y col., 2011).

Otro de los problemas, es que tipo de catéteres pueden implantarse de una forma crónica (Bienemann y col., 2012).

Bibliografía

Bienemann, A, E White, M Woolley, E Castrique, D E Johnson, M Wyatt, G Murray, H Taylor, N Barua, and S S Gill. 2012. "The Development of an Implantable Catheter System for Chronic or Intermittent Convection-enhanced Delivery." Journal of Neuroscience Methods 203 (2) (January 30): 284-291. doi:10.1016/j.jneumeth.2011.10.002.

Buonerba, Carlo, Giuseppe Di Lorenzo, Alfredo Marinelli, Piera Federico, Giovannella Palmieri, Martina Imbimbo, Pio Conti, Gianfranco Peluso, Sabino De Placido, and John H Sampson. 2011. "A comprehensive outlook on intracerebral therapy of malignant gliomas." Critical Reviews in Oncology/Hematology 80 (1) (October): 54-68. doi:10.1016/j.critrevonc.2010.09.001.

Mehta AI, Choi BD, Raghavan R, Brady M, Friedman AH, Bigner DD, Pastan I, Sampson JH. Imaging of convection enhanced delivery of toxins in humans. Toxins (Basel). 2011 Mar;3(3):201-6. Epub 2011 Mar 15. PubMed PMID: 22069706.

Shahar, Tal, Zvi Ram, and Andrew A Kanner. 2011. "Convection-enhanced delivery catheter placements for high-grade gliomas: complications and pitfalls." Journal of Neuro-Oncology (November 4). doi:10.1007/s11060-011-0751-x. http://www.ncbi.nlm.nih.gov/pubmed/22052334.

Bibliografía recomendada

1: Xi G, Rajaram V, Mania-Farnell B, Mayanil CS, Soares MB, Tomita T, Goldman S. Efficacy of vincristine administered via convection-enhanced delivery in a rodent brainstem tumor model documented by bioluminescence imaging. Childs Nerv Syst. 2012 Jan 27. [Epub ahead of print] PubMed PMID: 22282078.

2: White E, Bienemann A, Taylor H, Hopkins K, Cameron A, Gill S. A phase I trial of carboplatin administered by convection-enhanced delivery to patients with recurrent/progressive glioblastoma multiforme. Contemp Clin Trials. 2011 Nov 12. [Epub ahead of print] PubMed PMID: 22101221.

3: Mehta AI, Choi BD, Raghavan R, Brady M, Friedman AH, Bigner DD, Pastan I, Sampson JH. Imaging of convection enhanced delivery of toxins in humans. Toxins (Basel). 2011 Mar;3(3):201-6. Epub 2011 Mar 15. PubMed PMID: 22069706; PubMed Central PMCID: PMC3202819.

4: Shahar T, Ram Z, Kanner AA. Convection-enhanced delivery catheter placements for high-grade gliomas: complications and pitfalls. J Neurooncol. 2011 Nov 4. [Epub ahead of print] PubMed PMID: 22052334.

5: Bienemann A, White E, Woolley M, Castrique E, Johnson DE, Wyatt M, Murray G, Taylor H, Barua N, Gill SS. The development of an implantable catheter system for chronic or intermittent convection-enhanced delivery. J Neurosci Methods. 2012 Jan 30;203(2):284-91. Epub 2011 Oct 12. PubMed PMID: 22015599.

6: Rosenbluth KH, Eschermann JF, Mittermeyer G, Thomson R, Mittermeyer S, Bankiewicz KS. Analysis of a simulation algorithm for direct brain drug delivery. Neuroimage. 2012 Feb 1;59(3):2423-9. Epub 2011 Sep 14. PubMed PMID: 21945468; PubMed Central PMCID: PMC3254804.

7: Grossman R, Tyler B, Hwang L, Zadnik P, Lal B, Javaherian K, Brem H. Improvement in the standard treatment for experimental glioma by fusing antibody Fc domain to endostatin. J Neurosurg. 2011 Dec;115(6):1139-46. Epub 2011 Sep 16. PubMed PMID: 21923243.

8: White E, Bienemann A, Megraw L, Bunnun C, Wyatt M, Taylor H, Gill S. Distribution properties of lentiviral vectors administered into the striatum by convection-enhanced delivery. Hum Gene Ther. 2012 Jan;23(1):115-27. Epub 2011 Oct 19. PubMed PMID: 21793715.

9: Nakamura T, Saito R, Sugiyama S, Sonoda Y, Kumabe T, Tominaga T. Local convection-enhanced delivery of chemotherapeutic agent transiently opens blood-brain barrier and improves efficacy of systemic chemotherapy in intracranial xenograft tumor model. Cancer Lett. 2011 Nov 1;310(1):77-83. Epub 2011 Jun 28. PubMed PMID: 21763069.

10: Rainov NG, Heidecke V. Clinical Development of Experimental Virus-Mediated Gene Therapy for Malignant Glioma. Anticancer Agents Med Chem. 2011 Jun 27. [Epub ahead of print] PubMed PMID: 21707496.

11: Bruce JN, Fine RL, Canoll P, Yun J, Kennedy BC, Rosenfeld SS, Sands SA, Surapaneni K, Lai R, Yanes CL, Bagiella E, DeLaPaz RL. Regression of recurrent malignant gliomas with convection-enhanced delivery of topotecan. Neurosurgery. 2011 Dec;69(6):1272-9; discussion 1279-80. PubMed PMID: 21562434.

12: White E, Bienemann A, Malone J, Megraw L, Bunnun C, Wyatt M, Gill S. An evaluation of the relationships between catheter design and tissue mechanics in achieving high-flow convection-

enhanced delivery. J Neurosci Methods. 2011 Jul 15;199(1):87-97. Epub 2011 Apr 27. PubMed PMID: 21549753.

13: White E, Bienemann A, Taylor H, Castrique E, Bunnun C, Wyatt M, Gill S. An evaluation of site-specific immune responses directed against first-generation adenoviral vectors administered by convection-enhanced delivery. J Gene Med. 2011 May;13(5):269-82. doi: 10.1002/jgm.1567. PubMed PMID: 21544905.

14: Saito R, Sonoda Y, Kumabe T, Nagamatsu K, Watanabe M, Tominaga T. Regression of recurrent glioblastoma infiltrating the brainstem after convection-enhanced delivery of nimustine hydrochloride. J Neurosurg Pediatr. 2011 May;7(5):522-6. PubMed PMID: 21529193.

15: Rainov NG, Heidecke V. Clinical development of experimental therapies for malignant glioma. Sultan Qaboos Univ Med J. 2011 Feb;11(1):5-28. Epub 2011 Feb 12. PubMed PMID: 21509204; PubMed Central PMCID: PMC3074673.

16: Kogias E, Osterberg N, Baumer B, Psarras N, Koentges C, Papazoglou A, Saavedra JE, Keefer LK, Weyerbrock A. Growth-inhibitory and chemosensitizing effects of the glutathione-S-transferase-π-activated nitric oxide donor PABA/NO in malignant gliomas. Int J Cancer. 2012 Mar 1;130(5):1184-94. doi: 10.1002/ijc.26106. Epub 2011 Jul 21. PubMed PMID: 21455987; PubMed Central PMCID: PMC3161158.

17: Richardson RM, Gimenez F, Salegio EA, Su X, Bringas J, Berger MS, Bankiewicz KS. T2 imaging in monitoring of intraparenchymal real-time convection-enhanced delivery. Neurosurgery. 2011 Jul;69(1):154-63; discussion 163. PubMed PMID: 21430597.

18: Sampson JH, Brady M, Raghavan R, Mehta AI, Friedman AH, Reardon DA, Petry NA, Barboriak DP, Wong TZ, Zalutsky MR, Lally-Goss D, Bigner DD. Colocalization of gadolinium-diethylene triamine pentaacetic acid with high-molecular-weight molecules after intracerebral convection-enhanced delivery in humans. Neurosurgery. 2011 Sep;69(3):668-76. PubMed PMID: 21430586; PubMed Central PMCID: PMC3154565.

19: White E, Bienemann A, Megraw L, Bunnun C, Gill S. Evaluation and optimization of the administration of a selectively replicating herpes simplex viral vector to the brain by convection-enhanced delivery. Cancer Gene Ther. 2011 May;18(5):358-69. Epub 2011 Mar 4. PubMed PMID: 21372854.

20: Miyata S, Kawabata S, Hiramatsu R, Doi A, Ikeda N, Yamashita T, Kuroiwa T, Kasaoka S, Maruyama K, Miyatake S. Computed tomography imaging of transferrin targeting liposomes encapsulating both boron and iodine contrast agents by convection-enhanced delivery to F98 rat glioma for boron neutron capture therapy. Neurosurgery. 2011 May;68(5):1380-7; discussion 1387. PubMed PMID: 21273928.

21: Rosenbluth KH, Luz M, Mohr E, Mittermeyer S, Bringas J, Bankiewicz KS. Design of an in-dwelling cannula for convection-enhanced delivery. J Neurosci Methods. 2011 Mar 15;196(1):118-23. Epub 2010 Dec 25. PubMed PMID: 21187114.

22: Debinski W, Tatter SB. Convection-enhanced delivery to achieve widespread distribution of viral vectors: Predicting clinical implementation. Curr Opin Mol Ther. 2010 Dec;12(6):647-53. Review. PubMed PMID: 21154156.

23: White E, Woolley M, Bienemann A, Johnson DE, Wyatt M, Murray G, Taylor H, Gill SS. A robust MRI-compatible system to facilitate highly accurate stereotactic administration of therapeutic agents to

targets within the brain of a large animal model. J Neurosci Methods. 2011 Jan 30;195(1):78-87. Epub 2010 Nov 11. PubMed PMID: 21074564.

24: Carty N, Lee D, Dickey C, Ceballos-Diaz C, Jansen-West K, Golde TE, Gordon MN, Morgan D, Nash K. Convection-enhanced delivery and systemic mannitol increase gene product distribution of AAV vectors 5, 8, and 9 and increase gene product in the adult mouse brain. J Neurosci Methods. 2010 Dec 15;194(1):144-53. Epub 2010 Oct 15. PubMed PMID: 20951738; PubMed Central PMCID: PMC2995441.

25: Valles F, Fiandaca MS, Eberling JL, Starr PA, Larson PS, Christine CW, Forsayeth J, Richardson RM, Su X, Aminoff MJ, Bankiewicz KS. Qualitative imaging of adeno-associated virus serotype 2-human aromatic L-amino acid decarboxylase gene therapy in a phase I study for the treatment of Parkinson disease. Neurosurgery. 2010 Nov;67(5):1377-85. PubMed PMID: 20871425.

26: Kawabata S, Yang W, Barth RF, Wu G, Huo T, Binns PJ, Riley KJ, Ongayi O, Gottumukkala V, Vicente MG. Convection enhanced delivery of carboranylporphyrins for neutron capture therapy of brain tumors. J Neurooncol. 2011 Jun;103(2):175-85. Epub 2010 Sep 17. PubMed PMID: 20848301; PubMed Central PMCID: PMC3005081.

27: White E, Bienemann A, Sena-Esteves M, Taylor H, Bunnun C, Castrique E, Gill S. Evaluation and optimization of the administration of recombinant adeno-associated viral vectors (serotypes 2/1, 2/2, 2/rh8, 2/9, and 2/rh10) by convection-enhanced delivery to the striatum. Hum Gene Ther. 2011 Feb;22(2):237-51. Epub 2011 Feb 2. PubMed PMID: 20836701.

28: Panse SJ, Fillmore HL, Chen ZJ, Gillies GT, Broaddus WC. A novel coaxial tube catheter for central nervous system infusions: performance characteristics in brain phantom gel. J Med Eng Technol. 2010 Oct-Nov;35(7-8):408-14. PubMed PMID: 20807174.

29: Hadjipanayis CG, Machaidze R, Kaluzova M, Wang L, Schuette AJ, Chen H, Wu X, Mao H. EGFRvIII antibody-conjugated iron oxide nanoparticles for magnetic resonance imaging-guided convection-enhanced delivery and targeted therapy of glioblastoma. Cancer Res. 2010 Aug 1;70(15):6303-12. Epub 2010 Jul 20. PubMed PMID: 20647323; PubMed Central PMCID: PMC2912981.

30: Yokosawa M, Sonoda Y, Sugiyama S, Saito R, Yamashita Y, Nishihara M, Satoh T, Kumabe T, Yokoyama M, Tominaga T. Convection-enhanced delivery of a synthetic retinoid Am80, loaded into polymeric micelles, prolongs the survival of rats bearing intracranial glioblastoma xenografts. Tohoku J Exp Med. 2010;221(4):257-64. PubMed PMID: 20622491.

31: Yin D, Richardson RM, Fiandaca MS, Bringas J, Forsayeth J, Berger MS, Bankiewicz KS. Cannula placement for effective convection-enhanced delivery in the nonhuman primate thalamus and brainstem: implications for clinical delivery of therapeutics. J Neurosurg. 2010 Aug;113(2):240-8. PubMed PMID: 20367078.

32: Carpentier A, Metellus P, Ursu R, Zohar S, Lafitte F, Barrié M, Meng Y, Richard M, Parizot C, Laigle-Donadey F, Gorochov G, Psimaras D, Sanson M, Tibi A, Chinot O, Carpentier AF. Intracerebral administration of CpG oligonucleotide for patients with recurrent glioblastoma: a phase II study. Neuro Oncol. 2010 Apr;12(4):401-8. Epub 2010 Jan 25. PubMed PMID: 20308317; PubMed Central PMCID: PMC2940609.

33: Hadaczek P, Johnston L, Forsayeth J, Bankiewicz KS. Pharmacokinetics and bioactivity of glial cell line-derived factor (GDNF) and neurturin (NTN) infused into the rat brain. Neuropharmacology. 2010 Jun;58(7):1114-21. Epub 2010 Feb 11. PubMed PMID: 20153340; PubMed Central PMCID:

PMC2849906.

34: Dörner L, Nabavi A, Mehdorn HM. Entry points for catheter placement in convection-enhanced delivery–a retrospective anatomic analysis. Minim Invasive Neurosurg. 2009 Oct;52(5-6):229-32. Epub 2010 Jan 14. PubMed PMID: 20077363.

35: Yin D, Forsayeth J, Bankiewicz KS. Optimized cannula design and placement for convection-enhanced delivery in rat striatum. J Neurosci Methods. 2010 Mar 15;187(1):46-51. Epub 2009 Dec 22. PubMed PMID: 20026357; PubMed Central PMCID: PMC2865230.

36: Sampson JH, Archer G, Pedain C, Wembacher-Schröder E, Westphal M, Kunwar S, Vogelbaum MA, Coan A, Herndon JE, Raghavan R, Brady ML, Reardon DA, Friedman AH, Friedman HS, Rodríguez-Ponce MI, Chang SM, Mittermeyer S, Croteau D, Puri RK; PRECISE Trial Investigators. Poor drug distribution as a possible explanation for the results of the PRECISE trial. J Neurosurg. 2010 Aug;113(2):301-9. PubMed PMID: 20020841.

37: Kondo A, Goldman S, Lulla RR, Mania-Farnell B, Vanin EF, Sredni ST, Rajaram V, Soares MB, Tomita T. Longitudinal assessment of regional directed delivery in a rodent malignant glioma model. J Neurosurg Pediatr. 2009 Dec;4(6):592-8. PubMed PMID: 19951051.

38: Debinski W, Tatter SB. Convection-enhanced delivery for the treatment of brain tumors. Expert Rev Neurother. 2009 Oct;9(10):1519-27. Review. PubMed PMID: 19831841.

39: Yin D, Valles FE, Fiandaca MS, Bringas J, Gimenez F, Berger MS, Forsayeth J, Bankiewicz KS. Optimal region of the putamen for image-guided convection-enhanced delivery of therapeutics in human and non-human primates. Neuroimage. 2011 Jan;54 Suppl 1:S196-203. Epub 2009 Sep 15. PubMed PMID: 19761848; PubMed Central PMCID: PMC2895968.

40: Valles F, Fiandaca MS, Bringas J, Dickinson P, LeCouteur R, Higgins R, Berger M, Forsayeth J, Bankiewicz KS. Anatomic compression caused by high-volume convection-enhanced delivery to the brain. Neurosurgery. 2009 Sep;65(3):579-85; discussion 585-6. PubMed PMID: 19687704; PubMed Central PMCID: PMC2745991.

41: Westphal M, Lamszus K. Other experimental therapies for glioma. Recent Results Cancer Res. 2009;171:155-64. Review. PubMed PMID: 19322543.

42: Hadaczek P, Forsayeth J, Mirek H, Munson K, Bringas J, Pivirotto P, McBride JL, Davidson BL, Bankiewicz KS. Transduction of nonhuman primate brain with adeno-associated virus serotype 1: vector trafficking and immune response. Hum Gene Ther. 2009 Mar;20(3):225-37. PubMed PMID: 19292604; PubMed Central PMCID: PMC2730589.

43: Tange Y, Kondo A, Egorin MJ, Mania-Farnell B, Daneriallis GM, Nakazaki H, Sredni ST, Rajaram V, Goldman S, Soares MB, Tomita T. Interstitial continuous infusion therapy in a malignant glioma model in rats. Childs Nerv Syst. 2009 Jun;25(6):655-62. Epub 2009 Feb 11. PubMed PMID: 19212774.

44: Hall WA. Convection-enhanced delivery: neurosurgical issues. Curr Drug Targets. 2009 Feb;10(2):126-30. Review. PubMed PMID: 19199908.

45: Kikuchi T, Saito R, Sugiyama S, Yamashita Y, Kumabe T, Krauze M, Bankiewicz K, Tominaga T. Convection-enhanced delivery of polyethylene glycol-coated liposomal doxorubicin: characterization and efficacy in rat intracranial glioma models. J Neurosurg. 2008 Nov;109(5):867-73. PubMed PMID: 18976076.

46: Yin D, Valles FE, Fiandaca MS, Forsayeth J, Larson P, Starr P, Bankiewicz KS. Striatal volume differences between non-human and human primates. J Neurosci Methods. 2009 Jan 30;176(2):200-5. Epub 2008 Sep 2. PubMed PMID: 18809434; PubMed Central PMCID: PMC2662364.

47: Inoue T, Yamashita Y, Nishihara M, Sugiyama S, Sonoda Y, Kumabe T, Yokoyama M, Tominaga T. Therapeutic efficacy of a polymeric micellar doxorubicin infused by convection-enhanced delivery against intracranial 9L brain tumor models. Neuro Oncol. 2009 Apr;11(2):151-7. Epub 2008 Aug 28. PubMed PMID: 18755917; PubMed Central PMCID: PMC2718986.

48: Thomale UW, Tyler B, Renard VM, Dorfman B, Guarnieri M, Haberl HE, Jallo GI. Local chemotherapy in the rat brainstem with multiple catheters: a feasibility study. Childs Nerv Syst. 2009 Jan;25(1):21-8. Epub 2008 Aug 9. PubMed PMID: 18690465.

49: Sugiyama S, Yamashita Y, Kikuchi T, Sonoda Y, Kumabe T, Tominaga T. Enhanced antitumor effect of combined-modality treatment using convection-enhanced delivery of hydrophilic nitrosourea with irradiation or systemic administration of temozolomide in intracranial brain tumor xenografts. Neurol Res. 2008 Nov;30(9):960-7. Epub 2008 Jul 30. PubMed PMID: 18671903.

50: Cunningham J, Pivirotto P, Bringas J, Suzuki B, Vijay S, Sanftner L, Kitamura M, Chan C, Bankiewicz KS. Biodistribution of adeno-associated virus type-2 in nonhuman primates after convection-enhanced delivery to brain. Mol Ther. 2008 Jul;16(7):1267-75. Epub 2008 Jun 3. PubMed PMID: 18523450; PubMed Central PMCID: PMC2766605.

51: Rainov NG, Gorbatyuk K, Heidecke V. Clinical trials with intracerebral convection-enhanced delivery of targeted toxins in malignant glioma. Rev Recent Clin Trials. 2008 Jan;3(1):2-9. Review. PubMed PMID: 18474010.

52: Rainov NG, Söling A. Clinical studies with targeted toxins in malignant glioma. Rev Recent Clin Trials. 2006 May;1(2):119-31. Review. PubMed PMID: 18473963.

53: Olson JJ, Zhang Z, Dillehay D, Stubbs J. Assessment of a balloon-tipped catheter modified for intracerebral convection-enhanced delivery. J Neurooncol. 2008 Sep;89(2):159-68. Epub 2008 May 6. PubMed PMID: 18458816.

54: Sampson JH, Akabani G, Archer GE, Berger MS, Coleman RE, Friedman AH, Friedman HS, Greer K, Herndon JE 2nd, Kunwar S, McLendon RE, Paolino A, Petry NA, Provenzale JM, Reardon DA, Wong TZ, Zalutsky MR, Pastan I, Bigner DD. Intracerebral infusion of an EGFR-targeted toxin in recurrent malignant brain tumors. Neuro Oncol. 2008 Jun;10(3):320-9. Epub 2008 Apr 10. PubMed PMID: 18403491; PubMed Central PMCID: PMC2563054.

55: Daneshvar H, Nelms J, Muhammad O, Jackson H, Tkach J, Davros W, Peterson T, Vogelbaum MA, Bruchez MP, Toms SA. Imaging characteristics of zinc sulfide shell, cadmium telluride core quantum dots. Nanomedicine (Lond). 2008 Feb;3(1):21-9. PubMed PMID: 18393664.

56: Ferguson SD, Foster K, Yamini B. Convection-enhanced delivery for treatment of brain tumors. Expert Rev Anticancer Ther. 2007 Dec;7(12 Suppl):S79-85. Review. PubMed PMID: 18076322.

57: Vogelbaum MA, Sampson JH, Kunwar S, Chang SM, Shaffrey M, Asher AL, Lang FF, Croteau D, Parker K, Grahn AY, Sherman JW, Husain SR, Puri RK. Convection-enhanced delivery of cintredekin besudotox (interleukin-13-PE38QQR) followed by radiation therapy with and without temozolomide in newly diagnosed malignant gliomas: phase 1 study of final safety results. Neurosurgery. 2007

Nov;61(5):1031-7; discussion 1037-8. PubMed PMID: 18091279.

58: Aoki T, Hashimoto N, Matsutani M. Management of glioblastoma. Expert Opin Pharmacother. 2007 Dec;8(18):3133-46. Review. PubMed PMID: 18035958.

59: Tanner PG, Holtmannspötter M, Tonn JC, Goldbrunner R. Effects of drug efflux on convection-enhanced paclitaxel delivery to malignant gliomas: technical note. Neurosurgery. 2007 Oct;61(4):E880-2; discussion E882. PubMed PMID: 17986926.

60: Oh S, Odland R, Wilson SR, Kroeger KM, Liu C, Lowenstein PR, Castro MG, Hall WA, Ohlfest JR. Improved distribution of small molecules and viral vectors in the murine brain using a hollow fiber catheter. J Neurosurg. 2007 Sep;107(3):568-77. PubMed PMID: 17886557; PubMed Central PMCID: PMC2615393.

61: Lonser RR, Warren KE, Butman JA, Quezado Z, Robison RA, Walbridge S, Schiffman R, Merrill M, Walker ML, Park DM, Croteau D, Brady RO, Oldfield EH. Real-time image-guided direct convective perfusion of intrinsic brainstem lesions. Technical note. J Neurosurg. 2007 Jul;107(1):190-7. PubMed PMID: 17639894.

62: Rousseau J, Boudou C, Estève F, Elleaume H. Convection-enhanced delivery of an iodine tracer into rat brain for synchrotron stereotactic radiotherapy. Int J Radiat Oncol Biol Phys. 2007 Jul 1;68(3):943-51. PubMed PMID: 17544004.

63: Ferguson S, Lesniak MS. Convection enhanced drug delivery of novel therapeutic agents to malignant brain tumors. Curr Drug Deliv. 2007 Apr;4(2):169-80. Review. PubMed PMID: 17456036.

64: Sampson JH, Raghavan R, Brady ML, Provenzale JM, Herndon JE 2nd, Croteau D, Friedman AH, Reardon DA, Coleman RE, Wong T, Bigner DD, Pastan I, Rodríguez-Ponce MI, Tanner P, Puri R, Pedain C. Clinical utility of a patient-specific algorithm for simulating intracerebral drug infusions. Neuro Oncol. 2007 Jul;9(3):343-53. Epub 2007 Apr 13. PubMed PMID: 17435179; PubMed Central PMCID: PMC1907410.

65: Wu A, Oh S, Ericson K, Demorest ZL, Vengco I, Gharagozlou S, Chen W, Low WC, Ohlfest JR. Transposon-based interferon gamma gene transfer overcomes limitations of episomal plasmid for immunogene therapy of glioblastoma. Cancer Gene Ther. 2007 Jun;14(6):550-60. Epub 2007 Apr 6. PubMed PMID: 17415381.

66: Sampson JH, Brady ML, Petry NA, Croteau D, Friedman AH, Friedman HS, Wong T, Bigner DD, Pastan I, Puri RK, Pedain C. Intracerebral infusate distribution by convection-enhanced delivery in humans with malignant gliomas: descriptive effects of target anatomy and catheter positioning. Neurosurgery. 2007 Feb;60(2 Suppl 1):ONS89-98; discussion ONS98-9. PubMed PMID: 17297371.

67: Saito R, Kumabe T, Tominaga T. ["Disease targeting therapy" for neurosurgical disorders: molecular targeting and drug delivery]. No Shinkei Geka. 2006 Nov;34(11):1157-65. Japanese. PubMed PMID: 17087271.

68: Rustamzadeh E, Hall WA, Todhunter DA, Vallera VD, Low WC, Liu H, Panoskaltsis-Mortari A, Vallera DA. Intracranial therapy of glioblastoma with the fusion protein DTAT in immunodeficient mice. Int J Cancer. 2007 Jan 15;120(2):411-9. PubMed PMID: 17075792.

69: Sugiyama S, Yamashita Y, Kikuchi T, Saito R, Kumabe T, Tominaga T. Safety and efficacy of convection-enhanced delivery of ACNU, a hydrophilic nitrosourea, in intracranial brain tumor models. J Neurooncol. 2007 Mar;82(1):41-7. Epub 2006 Sep 20. PubMed PMID: 17031554.

70: Sathornsumetee S, Rich JN. New approaches to primary brain tumor treatment. Anticancer Drugs. 2006 Oct;17(9):1003-16. Review. PubMed PMID: 17001172.

71: Rainov NG, Söling A, Heidecke V. Novel therapies for malignant gliomas: a local affair? Neurosurg Focus. 2006 Apr 15;20(4):E9. Review. PubMed PMID: 16709040.

72: Kunwar S, Chang SM, Prados MD, Berger MS, Sampson JH, Croteau D, Sherman JW, Grahn AY, Shu VS, Dul JL, Husain SR, Joshi BH, Pedain C, Puri RK. Safety of intraparenchymal convection-enhanced delivery of cintredekin besudotox in early-phase studies. Neurosurg Focus. 2006 Apr 15;20(4):E15. PubMed PMID: 16709020.

73: Sampson JH, Akabani G, Friedman AH, Bigner D, Kunwar S, Berger MS, Bankiewicz KS. Comparison of intratumoral bolus injection and convection-enhanced delivery of radiolabeled antitenascin monoclonal antibodies. Neurosurg Focus. 2006 Apr 15;20(4):E14. PubMed PMID: 16709019.

74: Vandergrift WA, Patel SJ, Nicholas JS, Varma AK. Convection-enhanced delivery of immunotoxins and radioisotopes for treatment of malignant gliomas. Neurosurg Focus. 2006 Apr 15;20(4):E13. Review. PubMed PMID: 16709018.

75: Hall WA, Sherr GT. Convection-enhanced delivery: targeted toxin treatment of malignant glioma. Neurosurg Focus. 2006 Apr 15;20(4):E10. Review. PubMed PMID: 16709015.

76: Hall WA, Sherr GT. Convection-enhanced delivery of targeted toxins for malignant glioma. Expert Opin Drug Deliv. 2006 May;3(3):371-7. Review. PubMed PMID: 16640497.

77: Shapiro WR, Carpenter SP, Roberts K, Shan JS. (131)I-chTNT-1/B mAb: tumour necrosis therapy for malignant astrocytic glioma. Expert Opin Biol Ther. 2006 May;6(5):539-45. PubMed PMID: 16610983.

78: Pollack IF, Keating R. New delivery approaches for pediatric brain tumors. J Neurooncol. 2005 Dec;75(3):315-26. Review. PubMed PMID: 16195798.

79: Ohlfest JR, Demorest ZL, Motooka Y, Vengco I, Oh S, Chen E, Scappaticci FA, Saplis RJ, Ekker SC, Low WC, Freese AB, Largaespada DA. Combinatorial antiangiogenic gene therapy by nonviral gene transfer using the sleeping beauty transposon causes tumor regression and improves survival in mice bearing intracranial human glioblastoma. Mol Ther. 2005 Nov;12(5):778-88. Epub 2005 Sep 16. PubMed PMID: 16150649.

80: Mardor Y, Rahav O, Zauberman Y, Lidar Z, Ocherashvilli A, Daniels D, Roth Y, Maier SE, Orenstein A, Ram Z. Convection-enhanced drug delivery: increased efficacy and magnetic resonance image monitoring. Cancer Res. 2005 Aug 1;65(15):6858-63. PubMed PMID: 16061669.

81: Vogelbaum MA. Convection enhanced delivery for the treatment of malignant gliomas: symposium review. J Neurooncol. 2005 May;73(1):57-69. PubMed PMID: 15933820.

82: Patel SJ, Shapiro WR, Laske DW, Jensen RL, Asher AL, Wessels BW, Carpenter SP, Shan JS. Safety and feasibility of convection-enhanced delivery of Cotara for the treatment of malignant glioma: initial experience in 51 patients. Neurosurgery. 2005 Jun;56(6):1243-52; discussion 1252-3. PubMed PMID: 15918940.

83: Hall WA, Rustamzadeh E, Asher AL. Convection-enhanced delivery in clinical trials. Neurosurg Focus. 2003 Feb 15;14(2):e2. Review. PubMed PMID: 15727423.

84: Westphal M, Black PM. Perspectives of Cellular and Molecular Neurosurgery. J Neurooncol. 2004 Nov;70(2):257-271. PubMed PMID: 15674484.

85: Westphal M, Black PM. Perspectives of cellular and molecular neurosurgery. J Neurooncol. 2004 Nov;70(2):255-69. Review. PubMed PMID: 15674483.

86: Chen ZJ, Gillies GT, Broaddus WC, Prabhu SS, Fillmore H, Mitchell RM, Corwin FD, Fatouros PP. A realistic brain tissue phantom for intraparenchymal infusion studies. J Neurosurg. 2004 Aug;101(2):314-22. Review. PubMed PMID: 15309925.

87: Lidar Z, Mardor Y, Jonas T, Pfeffer R, Faibel M, Nass D, Hadani M, Ram Z. Convection-enhanced delivery of paclitaxel for the treatment of recurrent malignant glioma: a phase I/II clinical study. J Neurosurg. 2004 Mar;100(3):472-9. PubMed PMID: 15035283.

88: Sampson JH, Akabani G, Archer GE, Bigner DD, Berger MS, Friedman AH, Friedman HS, Herndon JE 2nd, Kunwar S, Marcus S, McLendon RE, Paolino A, Penne K, Provenzale J, Quinn J, Reardon DA, Rich J, Stenzel T, Tourt-Uhlig S, Wikstrand C, Wong T, Williams R, Yuan F, Zalutsky MR, Pastan I. Progress report of a Phase I study of the intracerebral microinfusion of a recombinant chimeric protein composed of transforming growth factor (TGF)-alpha and a mutated form of the Pseudomonas exotoxin termed PE-38 (TP-38) for the treatment of malignant brain tumors. J Neurooncol. 2003 Oct;65(1):27-35. PubMed PMID: 14649883.

89: Weber FW, Floeth F, Asher A, Bucholz R, Berger M, Prados M, Chang S, Bruce J, Hall W, Rainov NG, Westphal M, Warnick RE, Rand RW, Rommell F, Pan H, Hingorani VN, Puri RK. Local convection enhanced delivery of IL4-Pseudomonas exotoxin (NBI-3001) for treatment of patients with recurrent malignant glioma. Acta Neurochir Suppl. 2003;88:93-103. PubMed PMID: 14531567.

90: Voges J, Reszka R, Gossmann A, Dittmar C, Richter R, Garlip G, Kracht L, Coenen HH, Sturm V, Wienhard K, Heiss WD, Jacobs AH. Imaging-guided convection-enhanced delivery and gene therapy of glioblastoma. Ann Neurol. 2003 Oct;54(4):479-87. PubMed PMID: 14520660.

91: Mack WJ, Huang J, Winfree C, Kim G, Oppermann M, Dobak J, Inderbitzen B, Yon S, Popilskis S, Lasheras J, Sciacca RR, Pinsky DJ, Connolly ES Jr. Ultrarapid, convection-enhanced intravascular hypothermia: a feasibility study in nonhuman primate stroke. Stroke. 2003 Aug;34(8):1994-9. Epub 2003 Jun 26. PubMed PMID: 12829868.

92: Dunn IF, Black PM. The neurosurgeon as local oncologist: cellular and molecular neurosurgery in malignant glioma therapy. Neurosurgery. 2003 Jun;52(6):1411-22; discussion 1422-4. Review. PubMed PMID: 12762886.

93: Occhiogrosso G, Edgar MA, Sandberg DI, Souweidane MM. Prolonged convection-enhanced delivery into the rat brainstem. Neurosurgery. 2003 Feb;52(2):388-93; discussion 393-4. PubMed PMID: 12535369.

94: Debinski W. Local treatment of brain tumors with targeted chimera cytotoxic proteins. Cancer Invest. 2002;20(5-6):801-9. Review. PubMed PMID: 12197239.

95: Sandberg DI, Edgar MA, Souweidane MM. Effect of hyperosmolar mannitol on convection-enhanced delivery into the rat brain stem. J Neurooncol. 2002 Jul;58(3):187-92. PubMed PMID: 12187954.

96: Read TA, Thorsen F, Bjerkvig R. Localised delivery of therapeutic agents to CNS malignancies: old and new approaches. Curr Pharm Biotechnol. 2002 Sep;3(3):257-73. Review. PubMed PMID:

12164481.

97: Chen ZJ, Broaddus WC, Viswanathan RR, Raghavan R, Gillies GT. Intraparenchymal drug delivery via positive-pressure infusion: experimental and modeling studies of poroelasticity in brain phantom gels. IEEE Trans Biomed Eng. 2002 Feb;49(2):85-96. PubMed PMID: 12066887.

98: Sandberg DI, Edgar MA, Souweidane MM. Convection-enhanced delivery into the rat brainstem. J Neurosurg. 2002 May;96(5):885-91. PubMed PMID: 12005396.

99: Broaddus WC, Gillies GT, Kucharczyk J. Minimally invasive procedures. Advances in image-guided delivery of drug and cell therapies into the central nervous system. Neuroimaging Clin N Am. 2001 Nov;11(4):727-35. Review. PubMed PMID: 11995427.

100: Ratliff JK, Oldfield EH. Convection-enhanced delivery in intact and lesioned peripheral nerve. J Neurosurg. 2001 Dec;95(6):1001-11. PubMed PMID: 11765815.

101: Levy RM, Major E, Ali MJ, Cohen B, Groothius D. Convection-enhanced intraparenchymal delivery (CEID) of cytosine arabinoside (AraC) for the treatment of HIV-related progressive multifocal leukoencephalopathy (PML). J Neurovirol. 2001 Aug;7(4):382-5. Review. PubMed PMID: 11517421.

102: Kaiser MG, Parsa AT, Fine RL, Hall JS, Chakrabarti I, Bruce JN. Tissue distribution and antitumor activity of topotecan delivered by intracerebral clysis in a rat glioma model. Neurosurgery. 2000 Dec;47(6):1391-8; discussion 1398-9. PubMed PMID: 11126910.

103: Bruce JN, Falavigna A, Johnson JP, Hall JS, Birch BD, Yoon JT, Wu EX, Fine RL, Parsa AT. Intracerebral clysis in a rat glioma model. Neurosurgery. 2000 Mar;46(3):683-91. PubMed PMID: 10719865.

104: Lonser RR, Corthésy ME, Morrison PF, Gogate N, Oldfield EH. Convection-enhanced selective excitotoxic ablation of the neurons of the globus pallidus internus for treatment of parkinsonism in nonhuman primates. J Neurosurg. 1999 Aug;91(2):294-302. PubMed PMID: 10433318.

105: Lieberman DM, Corthesy ME, Cummins A, Oldfield EH. Reversal of experimental parkinsonism by using selective chemical ablation of the medial globus pallidus. J Neurosurg. 1999 May;90(5):928-34. PubMed PMID: 10223460.

106: Kroll RA, Pagel MA, Muldoon LL, Roman-Goldstein S, Neuwelt EA. Increasing volume of distribution to the brain with interstitial infusion: dose, rather than convection, might be the most important factor. Neurosurgery. 1996 Apr;38(4):746-52; discussion 752-4. PubMed PMID: 8692395.