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Liposomes as a Novel Drug Delivery System

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Abstract: *Liposomes and liposome-derived nanovesicles including archaeosomes and virosomes have turn out to be essential service structures in vaccine improvement and the hobby for liposome-primarily primarily based totally absolutely sincerely vaccines has markedly increased. A key gain of liposomes, archaeosomes and virosomes. In general, and liposome-primarily based totally sincerely vaccine transport structures in particular, is their versatility and plasticity. Liposome composition and training may be selected to attain preferred capabilities including choice of lipid, charge, length, length distribution, entrapment and region of antigens or adjuvants. Depending on the chemical properties, water- soluble antigens (proteins, peptides, nucleic acids, carbohydrates, haptens) are entrapped withinside the aqueous inner region of liposomes, at the equal time as lipophilic compounds (lipopeptides, antigens, adjuvants, linker molecules) are intercalated into the lipid bilayer and antigens or adjuvants may be related to the liposome ground each via adsorption or strong chemical linking. Co-formulations containing exclusive sorts of antigens or adjuvants may be blended with the parameters stated to tailor liposomal vaccines for character applications. Special emphasis is given on this overview to cationic adjuvant liposome vaccine formulations.*

Keywords: Archaeosomes, Liposomes, Liposomal Vaccine, Therapeutic Cancer Vaccines, Veterinary, Virosomes

I. INTRODUCTION

Classical vaccines rely upon using complete killed or attenuated pathogens. Today, studies is centered at the improvement of subunit vaccines due to the fact the a're higher defined, less difficult to provide and safer. Vaccines are synthetic on the idea of nicely characterised antigens, consisting of recombinant proteins and peptides. However, because of their artificial nature, their immune reaction is frequently weak, which is basically associated with the lack of ability of the antigens to set off maturation of dendritic cells (DCs), the number one antigen-supplying cells (APCs) that react to overseas pathogens and cause the immune reaction.[1] The immune system consists of the innate and the adaptive systems. The first is liable for first-line host protection, unexpectedly spotting and responding to overseas pathogens. The supplement device and phagocytic cells belong to this protection device which relies upon on sample reputation receptors (PRRs) that recognize pathogen-related molecular patternsToll-like receptors (TLRs) present on APCs are the receptors for pathogens containing PAMPs. TLR activation is the hallmark of innate immune response. The 2nd protection line, the adaptive immune device, mounts particular responses in opposition to molecular determinants on pathogenic agents. These responses are initiated via way of means of antigen-mediated triggering of T cells, the CD4+ T-helper (TH) cells, the CD8+ cytotoxic T lymphocytes (CTLs) and B lymphocytes sporting antigen-particular floor receptors. TH cells have subpopulations, of which TH1 and TH2 are the maximum important.[2] The numerous mechanisms through which nanoparticles result in immune responses are summarized in Figure 1. Activation of PRRs triggers the initiation of the innate immune reaction. Activated CTLs understand peptides certain to the foremost histocompatibility complex elegance I and II molecules (MHC-I, MHC-II), which particular antigenic peptides on APCs and bind to T cells thru the T-cell receptor. A costimulatory signal is wanted for complete CTL and TH cell activation which differentiate into TH1 or TH2 and different T-helper lineages that produce cytokines. TH cells offer assist to antigen-precise B cells, ensuing in antibody production.[3] Each invasion of a overseas antigen calls for activation of a particular kind of adaptive immune reaction for green manipulate and elimination. Thus, vaccine formulations must be designed rationally to result in precise shielding responses. This consists of the selection of antigen and adjuvant(s)

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and their pharmaceutical formulation.

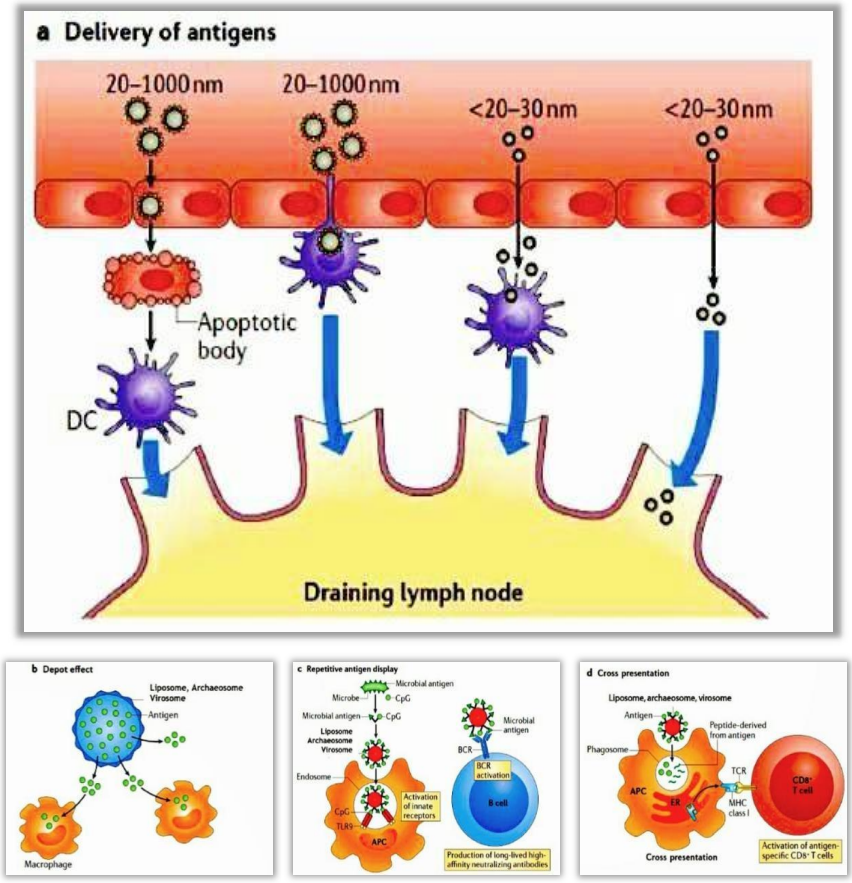

Figure 1: Mechanisms by which nanoparticles alter the induction of immune responses.[4]

II. ADJUVANT

The ability to enhance the immune reaction of vaccines with the aid of using certain compounds become first validated with aluminium salts, termed 'adjuvants', delivered to killed or attenuated pathogens. Their features have been associated with the cappotential to shape a depot which extended antigen exposure to APCs. However, efficient adjuvants additionally stimulate the immune device with the aid of using direct interplay with APCs. The nature of immune adjuvants is large and heterogeneous. Adjuvants are divided into immunostimulants and transport systems. Immunostimulants engage with particular receptors, like TLRs and others, at the same time as transport systems increase the immune response with the resource of the usage of more than one mechanisms, counting on their particular characteristics.[5] current vaccines contain adjuvants which include pathogen-derived subcellular components, recombinant proteins, peptides and nucleic acid sequences.[6] In addition, because of higher knowledge of the immune device and improvements in components technology, powerful therapeutic most cancers vaccines are developed.[7] Today's demanding situations in vaccine improvement are connected to complicated pathogens [e.g. malaria, tuberculosis, human immunodeficiency virus (HIV)] and to antigens liable to genetic mutations (e.g. influenza) in addition to topics with a compromised or dysfunctional immune system.[8] Nanoparticulate providers provide adjuvant activity with the aid of using improving antigen transport or with the aid of using activating innate immune responses. Strength and mechanisms of immunostimulation caused with the aid of using nano-carrier vaccines rely upon numerous factors, which include chemical composition, particle length and homogeneity, charge, nature and region of antigens and/or adjuvants inside the provider and, remaining however now no longer least, the site of administration.[9]

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III. Liposomes: Ideal Carriers For Antigens And Adjuvant

The capacity of liposomes to set off immune responses to protected or associated antigens end up first cited via Gregoriadis and Allison.[10] Since then, liposomes and liposome-derived nanovesicles inclusive of archaeosomes and virosomes have come to be crucial service structures and the interest for liposome-primarily based totally vaccines has markedly increased. The discipline of liposomes and liposome-primarily based totally vaccines is vast. Therefore, this evaluate concentrates on current reviews highlighting the maximum studied antigens and adjuvants in pertinent examples of vaccines, which includes summaries of veterinary and experimental healing most cancers vaccines. Other nano-particulate vaccines primarily based totally on lipoplexes, niosomes, virus-like particles, solid lipid nanoparticles and nanoemulsions aren't covered on this review.

A key benefit of liposomes, archaeosomes and virosomes in general, and liposome-primarily based totally delivery structures in particular, is their versatility and plasticity . Liposome composition and education may be selected to obtain favored functions together with lipid composition, charge, size, length distribution, entrapment and place of antigens or adjuvants. Depending at the chemical properties, water-soluble compounds (proteins, peptides, nucleic acids, carbohydrates, haptens) are entrapped withinside the aqueous internal space, while lipophilic compounds (lipopeptides, antigens, adjuvants, linker molecules) are intercalated into the lipid bilayer and antigens may be associated with the liposome ground every via way of way of adsorption or strong chemical linking[11] Coformulations containing exceptional varieties of antigens and adjuvants can be mixed to tailor liposomal vaccines for character applications (see Figure 2).

IV. Liposome-Based Antigens

A. Liposome-mediated effects of antigen uptake, trafficking, processing and presentation

As the majority of vaccines are administered through intramuscular or subcutaneous injection, liposome residences play a chief function in nearby tissue distribution, retention, trafficking, uptake and processing through APCs. Earlier research confirmed clean size-structured, however now no longer unambiguous charge or lipid composition structured outcomes on the injection site.[12] Newer research with the cationic liposome components dimethyl dioctadecylammonium (DDA) plus trehalose dibehenate (TDB) (DDA/TDB, CAF01) confirmed no variations in liposome draining or antigen launch from the injection site. However, variations in motion to nearby lymph nodes (LNs) have been noted.[13]

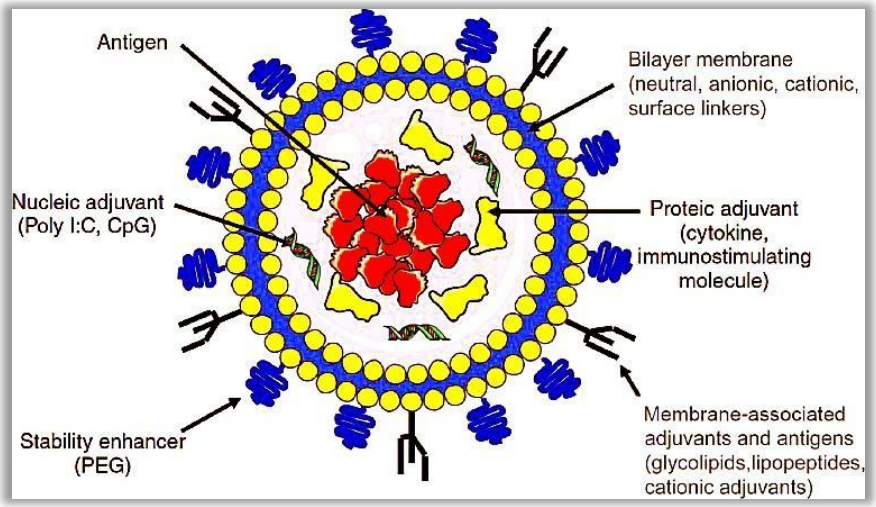

Figure 2: Schematic illustration of a small unilamellar liposome displaying the flexibility of incorporation of numerous compounds both with the aid of using encapsulation in aqueous internal area

A cationic liposome pDNA vaccine of 500 nm and 140 nm period with encapsulated ovalbumin (OVA) encoding pDNA as antigen showed maximum effective retention at huge vesicle period. Addition of poly(ethyleneglycol) (peg) coating caused extra acceptable lymphatic drainage, without advanced immune response.[14] A cationic liposome pDNA vaccine of 500 nm and 140 nm length with encapsulated ovalbumin (OVA) encoding pDNA as antigen confirmed most powerful

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retention at massive vesicle length. Addition of poly(ethyleneglycol) (peg) coating led to more desirable lymphatic drainage, with out stepped forward immune response.[15] Other pegylated DDA/TDB liposomes decreased the depot impact and adjusted the immune response, confirming those results.[16] Badiee and co-workers evaluated liposomes of various sizes containing the floor glycoprotein of Leishmania (rgp63). Immunization with small liposomes triggered a TH2 response, while huge liposomes triggered a TH1 response, better interferon γ (IFNγ) degrees and immunoglobulin IgG2a/IgG1 ratios.[17] Adjuvant outcomes of neutral, nice or negative liposomes had been evaluated whilst admixed with OVA, cationized OVA (cOVA) or Bacillus anthracis antigen through Yanasarn and colleagues. Immunization with OVA admixed with one of a kind liposomes generated one of a kind antibody responses. Interestingly, OVA admixed with poor 1,2-dioleyl-sn-glycero-3-phosphatidic acid liposomes turned into as immunogenic as OVA admixed with nice 1,2- dioleoyl-3-trimethyl ammonium propane liposomes. The cOVA antigen confirmed similar adjuvant activities in all liposomes.[18] Neutral phosphatidylcholine (PC)/ldl cholesterol small unilamellar vesicles (SUV) additionally proved to be powerful vaccine carriers. We evaluated a vaccine with peptides derived from the glycoprotein of the lymphocyticChoriomeningitis virus (LCMV). Liposome-encapsulated peptides have been highly immunogenic and elicited protecting antiviral immunity via way of means of in vivo antigen loading of DCs. Encapsulated cytosine– phosphorothioate–guanine oligodeoxynucleotides (CpGs) similarly superior immune activation.[19] We extensively utilized the vaccine to top a CD8+ T-cell reaction in opposition to 10 distinctive hepatitis C virus (HCV) epitopes, ensuing in strong CTL responses. Challenge experiments with Vaccinia virus expressing HCV epitopes emphasised the application of impartial liposomes as HCV vaccine.[20] Moon and colleagues describe novel interbilayer-crosslinked multilamellar vesicles (MLVs) shaped via way of means of crosslinking adjoining lipid bilayers inside MLVs. These vesicles entrapped protein antigens of their center and lipid-primarily based totally immunostimulatory molecules withinside the bilayers, forming a potent vaccine, eliciting strong T-cell and antibody responses.[21]

Investigation of hemagglutinin (HA) adsorption as opposed to encapsulation and coencapsulation of CpGs in 3β-[N-(N',N'-dimethylaminoethane)-carbamoyl] cholesterol (DC-chol) liposomes confirmed that adsorbed HA turned into greater immunogenic than encapsulated HA. Cholesterol better the adjuvant impact and CpG-loaded liposomes have been notably green at improving HA-precise humoral responses.[22] Covalent attachment of protein antigens to nanocarriers can disrupt protein shape and masks epitopes, changing the antibody response. Watson and associates used metallic chelation via nitrilotriacetic acid (NTA) to connect antigens to liposomes. OVA and a HIV-1 gp41 (N-MPR) peptide have been connected thru NTA or covalent linkage. Attachment of N-MPR, however now no longer OVA, elicited more potent antibody responses than antigen admixed with liposomes and covalent attachment turned into advanced to NTA-anchored antigens.[23] Mannose receptors (MRs) expressed on macrophages and APCs mediate endocytosis and cooperate in antigen seize and presentation. MRs recognize carbohydrate moieties of many pathogens. Thus, focused on of glycosylated antigens or provider structures to MRs is a way to develop vaccines.[24] To set up a human papilloma virus 16 (HPV16) most cancers vaccine, Mizuuchi and co-workers generated oligomannose liposomes containing HPV16-E6 plasmid antigens (OML-HPV). HPV16-E6-unique CTLs have been generated from HPV16- effective cervical carcinoma sufferers with OML-HPV, however now no longer with general liposomes.[25] OMLs in mixture with entrapped dsRNA to set off antihuman parainfluenza virus 3 (HPIV3) immunity have been studied with the aid of using Senchi and colleagues.[26] Hemagglutinin neuraminidase antigen become coencapsulated with adjuvant poly(I:C) into OMLs. Systemic and mucosal immune responses had been generated and immune sera suppressed viral contamination in vitro. Finally, Li and co-workers built a mannosylated liposome/protamine/DNA (Man-LPD) vaccine. Man-LPD exhibited better intracellular uptake and transfection in vitro and induction of costimulatory molecules on bone marrow DCs.[27]

B. Peptides and Proteins as Antigens

The antigen place in liposomes impacts immunogenicity. Both, entrapped or surface-connected. Antigens result in T-cellular responses, the latter having blessings of availability for antibody or B-cellular recognition, at the same time as encapsulated antigens require vesicle disruption to be accessible. The necessity of CD4+ T cells to activate memory CD8+ T cells come to be investigated in mice immunized with liposome surface-coupled OVA peptides. CTL responses had been brought on and showed in mice lacking CD4+ T cells, suggesting that CD4+ T cells had been not required for reminiscence CD8+ T-cellular generation.[28] Phosphatidylserine (PS)-liposome conjugated antigens have been successfully captured via way of means of APCs, ensuing in TH cell stimulation, validating PS as adjuvant for peptide vaccines.[29] Takagi and

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associates coupled numerous HCV peptides to liposomes. One Db-restricted and 3 HLA- A(*)0201-restricted peptides conferred entire safety to immunized mice and long-time period memory.[30] Liposome- encapsulated protein antigens were used regularly in in advance work. More recently, Nagill and associates in comparison encapsulated 78 kDa antigen of Leishmania donovani with antigen plus monophosphoryl lipid A (MPLA), ensuing in reduced parasite burden after challenge.[31]

In every other study, Bal and associates coencapsulated OVA and the TLR ligand Pam3CysSK4 or CpGs in dioleoyl-3-trimethyl ammonium propane (DOTAP) liposomes. Encapsulation of each ligands did now no longer impede activation of TLR-transfected cells and OVA/CpG liposomes shifted the IgG1/IgG2a stability to IgG2a, while Pam3CysSK4 become much less efficient.[32] Hepatitis B floor antigen (HBsAg) encapsulated liposomes coupled with Ulex europaeus agglutinin 1 had been advanced via way of means of Gupta and Vyas. Lectinized liposomes had been predominantly focused to M cells on intestinal Peyer's patches after oral immunization, yielding excessive antibody titers in mucosal secretions.[33] Another mucosal vaccine become defined by Figueiredo and co-workers who encapsulated Streptococcus equi- antigens in PC/cholesterol/stearylamine liposomes or chitosan nanoparticles. Intranasal immunization of mice elicited mucosal, humoral and cellular responses with better serum IgA ranges of the chitosan nanoparticles, because of superior mucoadhesive properties.[34] Liposomes changed with pH-touchy 3-methyl-glutarylated hyperbranched poly(glycidol) (MGlu-HPG) have been used to encapsulate OVA. MGlu-HPG liposomes triggered a strong immune reaction which changed into suppressed with anti-MHC-I/MHC-II antibodies.[35] Ding and associates advanced so-known as RAFTsomes through setting apart membrane microdomains containing MHC-I and I-Ab constrained epitopes from OVA-primed DCs and reconstituted them on liposome surfaces. RAFTsome immunization gave excessive anti-OVA IgG1 ranges and safety towards OVA-expressing EG.7 tumor challenge.[36]

C. Liposomal DNA Vaccines

Nucleic acid vaccines are an alternative to attenuated bacterial antigens or protein or peptide vaccines. With plasmids encoding bovine herpesvirus type 1. Vaccinated mice advanced particular IgG responses.[37] The M1 gene of influenza A virus changed into utilized by Liu and associates to assemble a cationic liposome/DNA vaccine with a M1-encoding plasmid for oral vaccination, ensuing in M1 gene expression in intestines of vaccinated mice and strong immune responses and safety towards task contamination.[38] Liposomes had been extensively utilized to supply plasmid DNA encoding warmth surprise protein 65 (hsp65) to deal with the pulmonary fungal contamination paracoccidiomycosis, ensuing in protecting immune reaction and decreased fungal burden.[39] Amidi and associates proposed liposomes as synthetic microbes that may be programmed to supply particular antigens for vaccination. A bacterial transcription and translation machine collectively with a gene assemble encoding β-galactosidase or a luciferase–nucleoprotein (NP) fusion epitope as antigens had been entrapped in liposomes. Vaccination of mice confirmed that such antigen-generating liposomes elicited better particular immune responses towards the produced antigen than manage vaccine.[40]

D. Liposomal Messenger RNA Vaccines

The immune device is obviously activated through overseas nucleic acids through inducing precise immune responses. Lack of persistence, genome integration and auto-antibody induction are blessings of mRNA and siRNA vaccines. Currently, mRNA vaccines are advanced to deal with numerous diseases, along with cancers. Pichon and Midoux loaded mannosylated nanoparticles with mRNA encoding a cancer antigen.[41] The mRNA became formulated with histidylated liposomes promoting endosome destabilization, permitting cytosolic nucleic acid transport which improved anti-B16F10 cancer vaccination in mice. A liposome encapsulated double-stranded RNA (LE-PolyICLC) became examined withinside the influenza (H5N1-HPIV) version through Li and colleagues. Intranasal LE-PolyICLC inhibited virus replication, decreased viral titers, extended survival of inflamed mice and attenuated pulmonary fibrosis.[42]

E. The MUC1 (BLP25) Antigens

The MUC1 glycoprotein is regularly overexpressed and hypoglycosylated in tumor cells of cancers, making it an appealing target for immunotherapy.[43] MUC1 variable variety tandem repeats conjugated to tumor-related carbohydrate antigens (TACAs) ruin self tolerance in humanized MUC1 transgenic mice. Sarkar and buddies formulated an anticancer vaccine composed of a MUC1 glycopeptide containing a GalNAc-O-Thr (Tn) TACA conjugated to a TLR ligand. Additional

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surface-displayed l-rhamnose (Rha) epitopes have been included in 1,2-dipalmitoyl-sn-glycero-3- phosphatidyl-choline (DPPC) liposomes. Mice have been immunized with a Rha-Ficoll conjugate accompanied via the vaccine, resulting in an growth in anti-MUC1-Tn greater than eightfold, anti-Tn antibody titers and elevated T-cellular proliferation.[44] Another liposome vaccine containing the immunoadjuvant Pam3CysSK4, a TH peptide epitope and a glycosylated MUC1 peptide become pronounced by Lakshminarayanan and colleagues. Covalent floor linkage of all 3 additives changed into critical for optimum efficacy.[45] The BLP25 liposome (L-BLP25) vaccine which targets MUC1 prolonged survival of sufferers with non-small cell lung most cancers (NSCLC) and confirmed promise in prostate most cancers.[46] Butts and co-workers performed section II/IIB research to assess L-BLP25 in sufferers with stage IIIA/IIIB NSCLC. Patients acquired both L-BLP25 plus exceptional supportive care (BSC) or BSC alone. Survival time and quotes had been longer in sufferers receiving the mixture as compared with BSC alone.[47] Wu and colleagues are carrying out an ongoing L-BLP25 observe (INSPIRE) in sufferers with NSCLC of East Asian ethnicity, that is the primary big therapeutic most cancers vaccine observe in an East-Asian population.[48]

V. Therapeutic Cancer Vaccines

Although maximum cancers adjust host proteins which can feature as antigens, the improvement of powerful vaccines in opposition to such antigens is hampered via way of means of the susceptible immune reaction and the immunosuppressive consequences precipitated via way of means of cancers.[49]

VI. Archaeosomes

Archaebacteria (Archaea) had been determined and categorized by Woese and Fox as a brand new organization of prokaryotes, except the Eubacteria (Bacteria).[50] Archaea comprise DNA-based RNA polymerases and proteinaceous cellular partitions that lack peptidoglycan. Their cell membranes are composed of L-glycerol ether lipids with isoprenoid chains in place of D-glycerol ester lipids with fatty acid chains.[51] Archaeal lipids are uniquely made out of ether-related isoprenoid phytanyl archaeol (diether) or caldarchaeol (tetraether) cores conferring excessive membrane stability. Archaeosomes are liposomes organized with archaeal glycerolipids. The head companies displayed at the glycerol lipid cores of archaeosomes have interaction with APCs and induce TH1, TH2 and CD8+ T-cell responses to the entrapped antigen. The immune responses are chronic and concern to strong memory responses.[52]

VII. Virosomes

Virosomes are liposomes organized by combining herbal or artificial phospholipids with virus envelope phospholipids, viral spike glycoproteins and different viral proteins. The first virosomes have been organized and characterised by Almeida and associates observed through Helenius and associates who protected Semliki Forest virus glycoproteins in liposomes.[53] Significant improvement grow to be made with virosomes termed 'immunopotentiating reconstituted influenza virosomes' (IRIVs). IRIVs are SUVs with spike projections of the influenza floor glycoproteins HA and neuraminidase. The fusogenic houses of HA are their number one features. IRIVs allow antigen presentation withinside the context of MHC-I and MHC-II and bring about B- and T-mobile responses.[54] The first virosome-based completely influenza vaccine applied in humans grow to be Inflexal V (Crucell NV, Leiden, The Netherlands), which has an great tolerability profile and immunogenicity in wholesome and immunocompromised humans.[55] Another virosome vaccine containing inactivated hepatitis A virus (HAV), Epaxal (Crucell NV, Leiden, The Netherlands), grow to be superior as hepatitis A vaccine. It is excellently tolerable and incredibly immunogenic, conferring protection of at least 9–eleven years in vaccinated individuals.[56] Immunogenicity and safety of Epaxal modified into evaluated in Thai youngsters with HIV infection. showing that Epaxal is an effective HAV vaccine for HIV-infected children.[57] Another vaccine consists of an aspartyl proteinase 2 (Sap2) of Candida albicans protected into IRIVs. Following intravaginal administration, anti- Sap2 antibodies have been detected in vaginal fluids of rats, inducing long-lasting protection.[58] Walczak and buddies verified that a heterologous top raise with Semliki Forest virus encoding a fusion protein of E6 and E7 of HPV16 and virosomes containing the HPV16-E7 protein brought about higher numbers of antigen-particular CTL in mice than homologous protocols.[59] Today, a 2nd era of influenza virosomes has advanced for numerous preclinical and scientific level vaccine candidates. Additional additives are protected to optimize particle meeting and balance and to decorate immunostimulatory effects.[60] GPI-0100, a saponin derivative, superior immunogenicity and protecting efficacy of a virosomal influenza vaccine, presenting complete safety of inflamed mice at

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extraordinarily low antigen doses.[61]

A aggregate of reconstituted breathing syncytial virus (RSV) envelopes with included MPLA (RSV-MPLA) virosomes changed into studied by Kamphuis and colleagues in more desirable breathing disease prone rats. Vaccination with RSV-MPLA brought about better antibody stages and safety towards infection.[62] Jamali and co-workers advanced a DNA vaccine the use of cationic influenza virosomes (CIV). CIV-brought epitope-encoding DNA brought about equal numbers of IFNγ and granzyme B-producing T cells than a 10-fold better dose of bare pDNA.[63] Another DNA/virosome vaccine changed into pronounced via way of means of Kheiri and colleagues, who organized a vaccine complicated containing an influenza NP-encoding plasmid that brought about a whole lot higher T-cellular responses and safety than plasmid alone.[64] In medical trials, IRIVs have proven significant ability for transport of peptides derived from Plasmodium falciparum antigens. An IRIV-formulated fusion protein composed of malaria antigens changed into defined by Tamborrini and colleagues.[65] Compared with different vaccines, the adjuvant-loose system elicited unique IgG1 antibody profiles in mice and pass reactivity with blood-level parasites.[66] Virosomes containing floor HIV-1 gp41- derived P1 lipid conjugated peptides (MYM-V101) as prophylactic HIV-1 vaccine have been organized. MYM-V101 changed into secure and properly tolerated while administered by intramuscular and intranasal routes in wholesome women. P1-specific serum IgGs and IgAs have been detected in all recipients however P1-unique TH1 responses have been now no longer found.[67]

VIII. Conclusion

The tremendous versatility of liposomes and the associated archaeosomes and virosomes endows them as noticeably precious service structures for vaccines. Besides enhancing antigen balance and presentation to immunocompetent cells, depending on their unique properties inclusive of composition, length and surface properties, those nanocarriers additionally own the capacity to overcome organic barriers, including pores and skin and mucosa, and provide managed and slow release of antigens. Together with the ability to result in strong immune responses supplied through coformulated adjuvants, liposome-primarily based totally vaccines provide properties which are essential for the improvement of current vaccine formulations. It is predictable that those transport structures might be increasingly carried out withinside the near future with success, main to predominant improvements in vaccine development.

References

[1]. Moser M, Leo O. Key concepts in immunology. Vaccine. 2010 Aug 31;28:C2-13.
[2]. Kawai T, Akira S. The role of pattern-recognition receptors in innate immunity: update on Toll-like receptors. Nature immunology. 2010 May;11(5):373-84.
[3]. Chen L, Flies DB. Molecular mechanisms of T cell co-stimulation and co-inhibition. Nature reviews immunology. 2013 Apr;13(4):227-42.
[4]. Smith DM, Simon JK, Baker Jr JR. Applications of nanotechnology for immunology. Nature Reviews Immunology. 2013 Aug;13(8):592-605.
[5]. Alving CR, Peachman KK, Rao M, Reed SG. Adjuvants for human vaccines. Current opinion in immunology. 2012 Jun 1;24(3):310-5.
[6]. Joshi MD, Unger WJ, Storm G, Van Kooyk Y, Mastrobattista E. Targeting tumor antigens to dendritic cells using particulate carriers. Journal of Controlled Release. 2012 Jul 10;161(1):25-37.
[7]. Leroux-Roels G. Unmet needs in modern vaccinology: adjuvants to improve the immune response. Vaccine. 2010 Aug 31;28:C25-36.
[8]. Watson DS, Endsley AN, Huang L. Design considerations for liposomal vaccines: influence of formulation parameters on antibody and cell- mediated immune responses to liposome associated antigens. Vaccine. 2012 Mar 16;30(13):2256-72.
[9]. Heegaard PM, Dedieu L, Johnson N, Le Potier MF, Mockey M, Mutinelli F, Vahlenkamp T, Vascellari M, Sørensen NS. Adjuvants and delivery systems in veterinary vaccinology: current state and future developments. Archives of virology. 2011 Feb;156(2):183-202.
[10]. Allison AC, Gregoriadis G. Liposomes as immunological adjuvants. Nature. 1974 Nov;252(5480):252-.
[11]. Torchilin VP. Recent advances with liposomes as pharmaceutical carriers. Nature reviews Drug discovery. 2005 Feb;4(2):145-60.

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[12]. Oussoren C, Zuidema J, Crommelin DJ, Storm G. Lymphatic uptake and biodistribution of liposomes after subcutaneous injection I. Influence of the anatomical site of injection. Journal of Liposome Research. 1997 Jan 1;7(1):85-99.

[13]. Henriksen-Lacey M, Bramwell VW, Christensen D, Agger EM, Andersen P, Perrie Y. Liposomes based on dimethyldioctadecylammonium promote a depot effect and enhance immunogenicity of soluble antigen. Journal of controlled release. 2010 Mar 3;142(2):180-6.

[14]. Carstens MG, Camps MG, Henriksen-Lacey M, Franken K, Ottenhoff TH, Perrie Y, Bouwstra JA, Ossendorp F, Jiskoot W. Effect of vesicle size on tissue localization and immunogenicity of liposomal DNA vaccines. Vaccine. 2011 Jun 24;29(29-30):4761-70.

[15]. Kaur R, Bramwell VW, Kirby DJ, Perrie Y. Pegylation of DDA: TDB liposomal adjuvants reduces the vaccine depot effect and alters the Th1/Th2 immune responses. Journal of controlled release. 2012 Feb 28;158(1):72-7.

[16]. Badiee A, Khamesipour A, Samiei A, Soroush D, Shargh VH, Kheiri MT, Barkhordari F, Mc Master WR, Mahboudi F, Jaafari MR. The role of liposome size on the type of immune response induced in BALB/c mice against leishmaniasis: rgp63 as a model antigen. Experimental parasitology. 2012 Dec 1;132(4):403-9.

[17]. Yanasarn N, Sloat BR, Cui Z. Negatively charged liposomes show potent adjuvant activity when simply admixed with protein antigens. Molecular pharmaceutics. 2011 Aug 1;8(4):1174-85.

[18]. Ludewig B, Barchiesi F, Pericin M, Zinkernagel RM, Hengartner H, Schwendener RA. In vivo antigen loading and activation of dendritic cells via a liposomal peptide vaccine mediates protective antiviral and anti-tumour immunity. Vaccine. 2000 Aug 15;19(1):23-32.

[19]. Engler OB, Schwendener RA, Dai WJ, Wölk B, Pichler W, Moradpour D, Brunner T, Cerny A. A liposomal peptide vaccine inducing CD8+ T cells in HLA-A2. 1 transgenic mice, which recognise human cells encoding hepatitis C virus (HCV) proteins. Vaccine. 2004 Nov 15;23(1):58- 68.

[20]. Moon JJ, Suh H, Bershteyn A, Stephan MT, Liu H, Huang B, Sohail M, Luo S, Ho Um S, Khant H, Goodwin JT. Interbilayer-crosslinked multilamellar vesicles as synthetic vaccines for potent humoral and cellular immune responses. Nature materials. 2011 Mar;10(3):243-51.

[21]. Quer CB, Elsharkawy A, Romeijn S, Kros A, Jiskoot W. Cationic liposomes as adjuvants for influenza hemagglutinin: more than charge alone. European journal of pharmaceutics and biopharmaceutics. 2012 Jun 1;81(2):294-302.

[22]. Watson DS, Platt VM, Cao L, Venditto VJ, Szoka Jr FC. Antibody response to polyhistidine-tagged peptide and protein antigens attached to liposomes via lipid-linked nitrilotriacetic acid in mice. Clinical and Vaccine Immunology. 2011 Feb;18(2):289-97.

[23]. Irache JM, Salman HH, Gamazo C, Espuelas S. Mannose-targeted systems for the delivery of therapeutics. Expert opinion on drug delivery. 2008 Jun 1;5(6):703-24.

[24]. Mizuuchi M, Hirohashi Y, Torigoe T, Kuroda T, Yasuda K, Shimizu Y, Saito T, Sato N. Novel oligomannose liposome-DNA complex DNA vaccination efficiently evokes anti-HPV E6 and E7 CTL responses. Experimental and molecular pathology. 2012 Feb 1;92(1):185-90.

[25]. Senchi K, Matsunaga S, Hasegawa H, Kimura H, Ryo A. Development of oligomannose-coated liposome-based nasal vaccine against human parainfluenza virus type 3. Frontiers in microbiology. 2013 Nov 26;4:346.

[26]. Li P, Chen S, Jiang Y, Jiang J, Zhang Z, Sun X. Dendritic cell targeted liposomes–protamine–DNA complexes mediated by synthetic mannosylated cholestrol as a potential carrier for DNA vaccine. Nanotechnology. 2013 Jun 25;24(29):295101.

[27]. Taneichi M, Tanaka Y, Kakiuchi T, Uchida T. Liposome-coupled peptides induce long-lived memory CD8+ T cells without CD4+ T cells. PLoS One. 2010 Nov 30;5(11):e15091.

[28]. Ichihashi T, Satoh T, Sugimoto C, Kajino K. Emulsified phosphatidylserine, simple and effective peptide carrier for induction of potent epitope- specific T cell responses. PLoS One. 2013 Mar 22;8(3):e60068.

[29]. Takagi A, Kobayashi N, Taneichi M, Uchida T, Akatsuka T. Coupling to the surface of liposomes alters the immunogenicity of hepatitis C virus- derived peptides and confers sterile immunity. Biochemical and Biophysical Research Communications. 2013 Jan 4;430(1):183-9.

[30]. Nagill R, Kaur S. Enhanced efficacy and immunogenicity of 78ákDa antigen formulated in various adjuvants

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against murine visceral leishmaniasis. Vaccine. 2010 May 21;28(23):4002-12.

[31]. Bal SM, Hortensius S, Ding Z, Jiskoot W, Bouwstra JA. Co-encapsulation of antigen and Toll-like receptor ligand in cationic liposomes affects the quality of the immune response in mice after intradermal vaccination. Vaccine. 2011 Jan 29;29(5):1045-52.

[32]. Gupta PN, Vyas SP. Investigation of lectinized liposomes as M-cell targeted carrier-adjuvant for mucosal immunization. Colloids and surfaces B: Biointerfaces. 2011 Jan 1;82(1):118-25.

[33]. Figueiredo L, Cadete A, Gonçalves LM, Corvo ML, Almeida AJ. Intranasal immunisation of mice against Streptococcus equi using positively charged nanoparticulate carrier systems. Vaccine. 2012 Oct 12;30(46):6551-8.

[34]. Hebishima T, Yuba E, Kono K, Takeshima SN, Ito Y, Aida Y. The pH-sensitive fusogenic 3-methyl-glutarylated hyperbranched poly (glycidol)- conjugated liposome induces antigen-specific cellular and humoral immunity. Clinical and Vaccine Immunology. 2012 Sep;19(9):1492-8.

[35]. Ding Q, Chen J, Wei X, Sun W, Mai J, Yang Y, Xu Y. RAFTsomes containing epitope-MHC-II complexes mediated CD4+ T cell activation and antigen-specific immune responses. Pharmaceutical research. 2013 Jan;30(1):60-9.

[36]. Rodriguez AE, Zamorano P, Wilkowsky S, Torrá F, Ferreri L, Dominguez M, Florin-Christensen M. Delivery of recombinant vaccines against bovine herpesvirus type 1 gD and Babesia bovis MSA-2c to mice using liposomes derived from egg yolk lipids. The Veterinary Journal. 2013 Jun 1;196(3):550-1.

[37]. Liu J, Wu J, Wang B, Zeng S, Qi F, Lu C, Kimura Y, Liu B. Oral vaccination with a liposome-encapsulated influenza DNA vaccine protects mice against respiratory challenge infection. Journal of medical virology. 2014 May;86(5):886-94.

[38]. Ribeiro AM, Souza AC, Amaral AC, Vasconcelos NM, Jeronimo MS, Carneiro FP, Faccioli LH, Felipe MS, Silva CL, Bocca AL.Nanobiotechnological approaches to delivery of DNA vaccine against fungal infection. Journal of biomedical nanotechnology. 2013 Feb 1;9(2):221-30.

[39]. Amidi M, de Raad M, Crommelin DJ, Hennink WE, Mastrobattista E. Antigen-expressing immunostimulatory liposomes as a genetically programmable synthetic vaccine. Systems and synthetic biology. 2011 Jun;5(1):21-31.

[40]. Pichon C, Midoux P. Mannosylated and histidylated LPR technology for vaccination with tumor antigen mRNA. Synthetic Messenger RNA and Cell Metabolism Modulation. 2013:247-74.

[41]. Li Y, Hu Y, Jin Y, Zhang G, Wong J, Sun LQ, Wang M. Prophylactic, therapeutic and immune enhancement effect of liposome-encapsulated PolyICLC on highly pathogenic H5N1 influenza infection. The journal of gene medicine. 2011 Jan;13(1):60-72.

[42]. Acres B, Limacher JM. MUC1 as a target antigen for cancer immunotherapy. Expert review of vaccines. 2005 Aug 1;4(4):493-502.

[43]. Sarkar, S., Salyer, A., Wall, K., Sucheck, S. (2013) Synthesis and immunological evaluation of a MUC1 glycopeptide incorporated into l- rhamnose displaying liposomes. Bioconjug Chem 24: 363–375.

[44]. Lakshminarayanan V, Thompson P, Wolfert MA, Buskas T, Bradley JM, Pathangey LB, Madsen CS, Cohen PA, Gendler SJ, Boons GJ. Immune recognition of tumor-associated mucin MUC1 is achieved by a fully synthetic aberrantly glycosylated MUC1 tripartite vaccine. Proceedings of the National Academy of Sciences. 2012 Jan 3;109(1):261-6.

[45]. North S, Butts C. Vaccination with BLP25 liposome vaccine to treat non-small cell lung and prostate cancers. Expert Review of Vaccines. 2005 Jun 1;4(3):249-57.

[46]. Butts C, Murray RN, Smith CJ, Ellis PM, Jasas K, Maksymiuk A, Goss G, Ely G, Beier F, Soulières D. A Multicenter Open-Label Study to Assess the Safety of a New Formulation of BLP25 Liposome Vaccine in Patients With Unresectable Stage III Non–Small-Cell Lung Cancer. Clinical Lung Cancer. 2010 Nov 1;11(6):391-5.

[47]. Wu YL, Park K, Soo RA, Sun Y, Tyroller K, Wages D, Ely G, Yang JC, Mok T. INSPIRE: a phase III study of the BLP25 liposome vaccine (L-BLP25) in Asian patients with unresectable stage III non-small cell lung cancer. BMC cancer. 2011 Dec;11(1):1-7.

[48]. Ohyanagi F, Horai T, Sekine I, Yamamoto N, Nakagawa K, Nishio M, Senger S, Morsli N, Tamura T. Safety of BLP25 liposome vaccine (L- BLP25) in Japanese patients with unresectable stage III NSCLC after primary chemoradiotherapy: preliminary results from a Phase I/II study. Japanese journal of clinical oncology. 2011 May

1;41(5):718-22.

[49]. Kozako T, Arima N, Yoshimitsu M, Honda SI, Soeda S. Liposomes and nanotechnology in drug development: focus on oncotargets. International Journal of Nanomedicine. 2012;7:4943.

[50]. Woese CR, Fox GE. Phylogenetic structure of the prokaryotic domain: the primary kingdoms. Proceedings of the National Academy of Sciences. 1977 Nov 1;74(11):5088-90.

[51]. Pang Y, Zhang Y, Wang H, Jin J, Piao J, Piao J, Liu Q, Li W. Reduction of Salmonella enteritidis number after infections by immunization of liposome-associated recombinant SefA. Avian diseases. 2013 Sep;57(3):627-33.

[52]. Krishnan L, Sprott GD. Archaeosome adjuvants: immunological capabilities and mechanism (s) of action. Vaccine. 2008 Apr 16;26(17):2043- 55.

[53]. Almeida J, Edwards DC, Brand C, Heath T. Formation of virosomes from influenza subunits and liposomes. The Lancet. 1975 Nov 8;306(7941):899-901.

[54]. Glück R. Immunopotentiating reconstituted influenza virosomes (IRIVs) and other adjuvants for improved presentation of small antigens. Vaccine. 1992 Jan 1;10(13):915-9.

[55]. Zamparo E, Little D. Immunogenicity and effectiveness of virosomal adjuvanted vaccines against influenza: a brief review of their utility in the elderly population. J Prev Med Hyg. 2011 Sep 1;52(3):116-9.

[56]. Ambrosch F, Wiedermann G, Jonas S, Althaus B, Finkel B, Glück R, Herzog C. Immunogenicity and protectivity of a new liposomal hepatitis A vaccine. Vaccine. 1997 Aug 1;15(11):1209-13.

[57]. Saksawad R, Likitnukul S, Warachit B, Hanvivatvong O, Poovorawan Y, Puripokai P. Immunogenicity and safety of a pediatric dose virosomal hepatitis A vaccine in Thai HIV-infected children. Vaccine. 2011 Jun 24;29(29-30):4735-8.

[58]. De Bernardis F, Amacker M, Arancia S, Sandini S, Gremion C, Zurbriggen R, Moser C, Cassone A. A virosomal vaccine against candidal vaginitis: immunogenicity, efficacy and safety profile in animal models. Vaccine. 2012 Jun 22;30(30):4490-8.

[59]. Walczak M, de Mare A, Riezebos-Brilman A, Regts J, Hoogeboom BN, Visser JT, Fiedler M, Jansen-Dürr P, van der Zee AG, Nijman HW, Wilschut J. Heterologous prime-boost immunizations with a virosomal and an alphavirus replicon vaccine. Molecular pharmaceutics. 2011 Feb 7;8(1):65-77.

[60]. Moser C, Müller M, Kaeser MD, Weydemann U, Amacker M. Influenza virosomes as vaccine adjuvant and carrier system. Expert review of vaccines. 2013 Jul 1;12(7):779-91.

[61]. Liu H, de Vries-Idema J, Ter Veer W, Wilschut J, Huckriede A. Influenza virosomes supplemented with GPI-0100 adjuvant: a potent vaccine formulation for antigen dose sparing. Medical microbiology and immunology. 2014 Feb;203(1):47-55.

[62]. Kamphuis T, Stegmann T, Meijerhof T, Wilschut J, de Haan A. A virosomal respiratory syncytial virus vaccine adjuvanted with monophosphoryl lipid A provides protection against viral challenge without priming for enhanced disease in cotton rats. Influenza and other respiratory viruses. 2013 Nov;7(6):1227-36.

[63]. Jamali A, Holtrop M, de Haan A, Hashemi H, Shenagari M, Memarnejadian A, Roohvand F, Sabahi F, Kheiri MT, Huckriede A. Cationic influenza virosomes as an adjuvanted delivery system for CTL induction by DNA vaccination. Immunology letters. 2012 Nov 1;148(1):77-82.

[64]. Kheiri MT, Jamali A, Shenagari M, Hashemi H, Sabahi F, Atyabi F, Saghiri R. Influenza virosome/DNA vaccine complex as a new formulation to induce intra-subtypic protection against influenza virus challenge. Antiviral research. 2012 Sep 1;95(3):229-36.

[65]. Peduzzi E, Westerfeld N, Zurbriggen R, Pluschke G, Daubenberger CA. Contribution of influenza immunity and virosomal-formulated synthetic peptide to cellular immune responses in a phase I subunit malaria vaccine trial. Clinical Immunology. 2008 May 1;127(2):188-97.

[66]. Tamborrini M, Stoffel SA, Westerfeld N, Amacker M, Theisen M, Zurbriggen R, Pluschke G. Immunogenicity of a virosomally-formulated Plasmodium falciparum GLURP-MSP3 chimeric protein-based malaria vaccine candidate in comparison to adjuvanted formulations. Malaria journal. 2011 Dec;10(1):1-1.